Varieties of the NIS (National Innovation Systems) and RIS (regional innov. Systems) around the World:

Measurement and Analysis using patent citation data

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Nelson/Lundvall (1992):
a key concept in Schumpeterian economics

NIS (national Innovation system) =

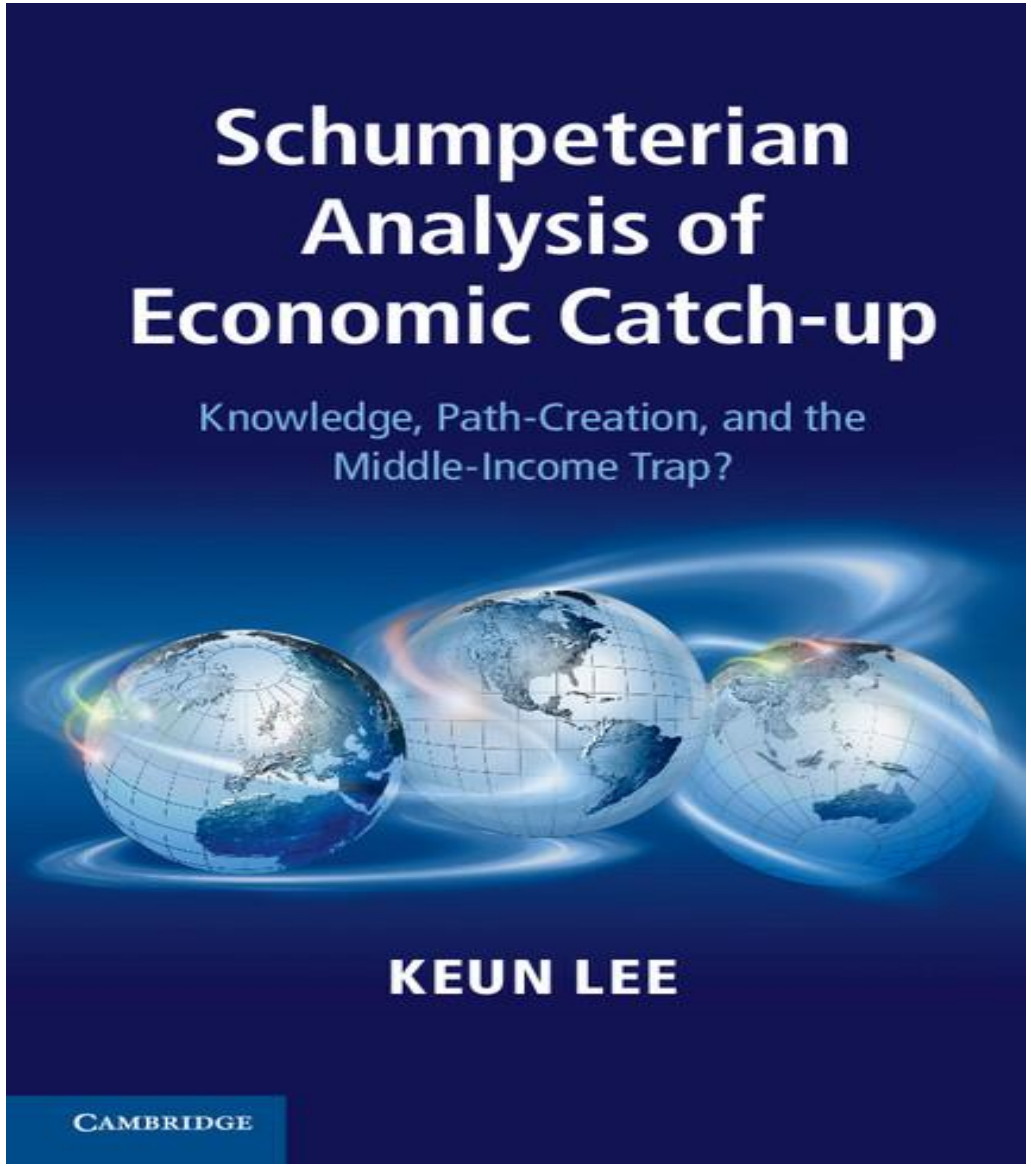
Elements and relationships
which interact in the production, diffusion and use of knowledge

-> **Differences in NIS determines competitiveness of nations, sectors and firms.**

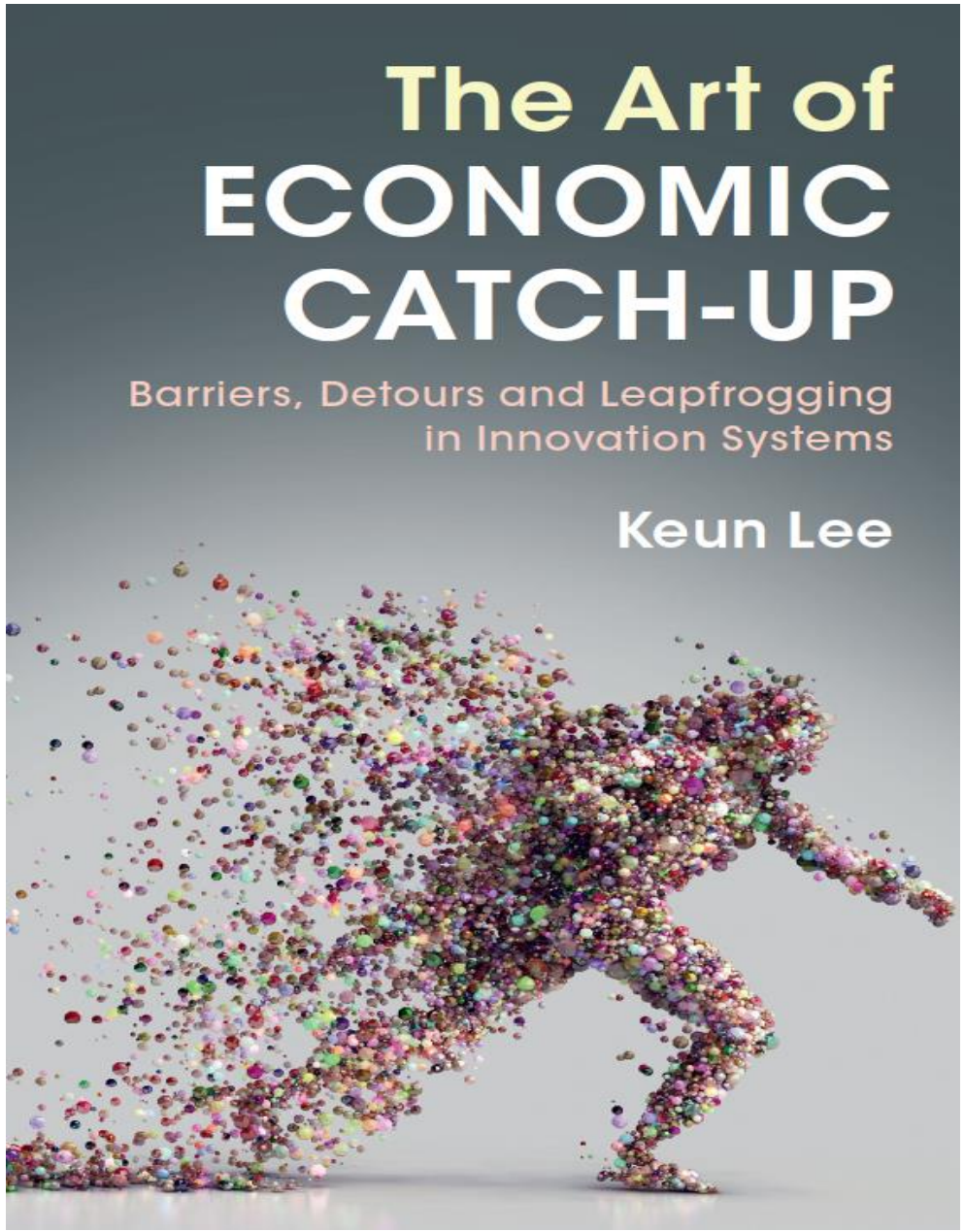
=> ***System failure cf) market failure***

Lee (2013) Innovation systems at 3 Levels: country; Sector; firm

=> 2014 Schumpeter Prize



Cambridge Univ. Press, 2019



Several Levels of Innovation systems:

1) Macro: National Innovation Systems = NIS

2) Meso: Sectoral = Sectoral SI (SSI)

Regional = Regional IS (RIS)

3) Micro: Corporate innovation systems (CIS)

Q: How to measure Innovations systems:

1) many variables from diverse sources

vs. 2) several key variables from the same sources (patents)

Eg) ***1) Knowledge localization, 2) tech diversifications 3) originality***

4) Concentrations, 5) cycle time of technologies (CTT)

A talk drawing upon 3/4 papers

•Lee, K., & Lee, J. (2019). National innovation systems, economic complexity, & economic growth. *J of Evolutionary Economics*, 1-32.

•Lee, Keun, et al. (2021). "Variety of National Innovation Systems (NIS) and Alternative Pathways to Growth beyond the Middle-Income Stage," *World Development*

•Kim, J., and Keun Lee (2022), "Local–Global Interface as a Key Factor in the Catching Up of Regional Innovation Systems: Fast versus Slow Catching Up among Taipei, Shenzhen, and Penang in Asia," *Technological Forecasting and Social Change*,

* RIS Analysis: **30 cities/regions around world;**
-> working paper (Utrecht Univ, Evolutionary Economic Geography Group, Ron Boschma)
https://peeg.wordpress.com/2022/10/06/22-19-varieties-of-regional-innovation-systems-around-the-world-and-catch-up-by-latecomers/

⇒**Key question: identification of different varieties of NIS/RIS; cf) VoC (capitalism)**
to link them to different performance

- eg) mature/advanced RIS/NIS; catching up or trapped NIS/RIS in EEs

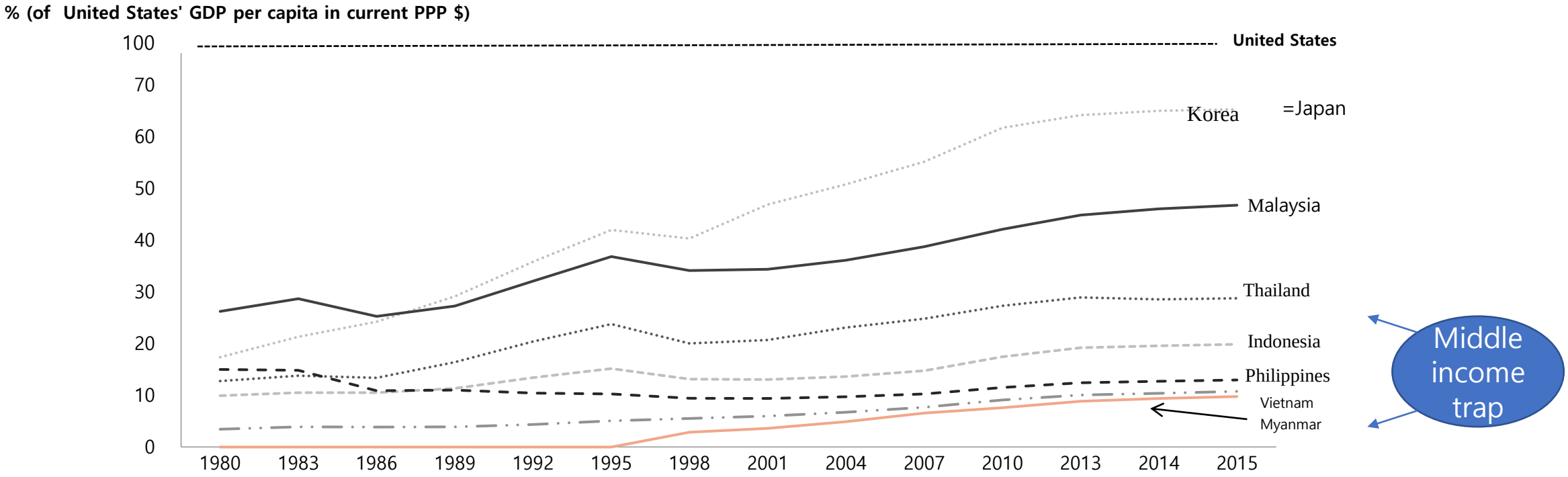
Varieties of the NIS (National Innovation Systems) around the World:

Alternative Pathways for Growth beyond the Mid. income trap; catching up vs. trapped NIS

(Lee et al 2021, WD)

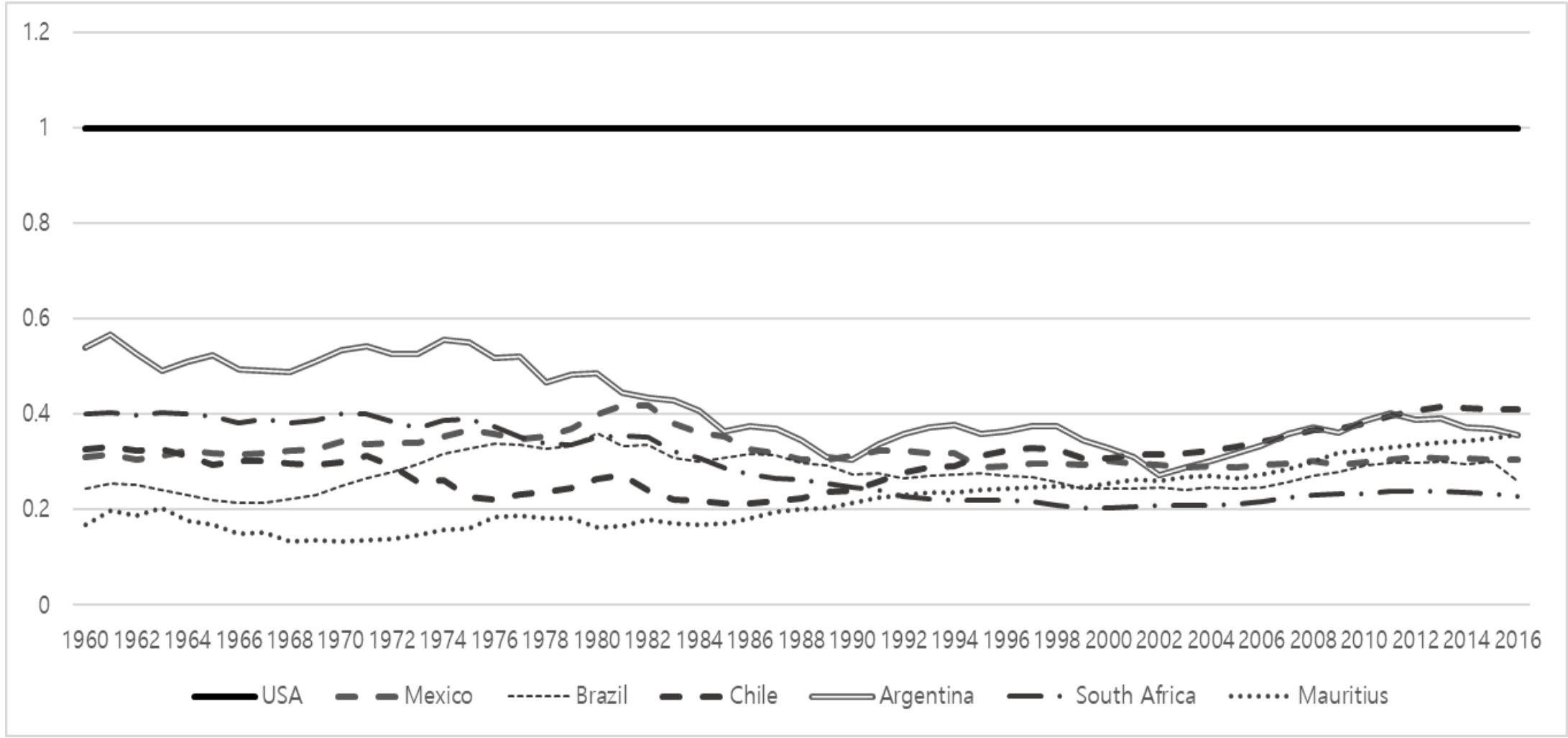
Korean Catch-up beyond the MIT (Middle income trap)

MIT = 20- 40% % of US GDP per capita (ppp $) for several decades: Thailand, Indonesia, Philippines, Vietnam, Myanmar



	1980	1983	1986	1989	1992	1995	1998	2001	2004	2007	2010	2013	2014	2015
United States	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Korea	17.4	21.3	24.2	29.1	35.8	42.0	40.3	46.9	50.8	55.1	61.7	64.2	65.0	65.3
Malaysia	26.2	28.7	25.3	27.3	32.1	36.8	34.1	34.4	36.1	38.7	42.1	44.8	46.0	46.7
Thailand	12.8	13.8	13.4	16.4	20.4	23.8	20.0	20.7	23.1	24.8	27.3	28.9	28.6	28.8
Indonesia	9.9	10.5	10.5	11.4	13.4	15.2	13.1	13.0	13.6	14.7	17.5	19.2	19.6	19.9
Philippines	15.0	14.9	10.9	11.0	10.4	10.2	9.4	9.4	9.7	10.2	11.5	12.4	12.7	13.0
Vietnam	3.5	3.9	3.9	3.9	4.4	5.1	5.5	6.0	6.7	7.7	9.1	10.1	10.4	10.8
Myanmar	0.0	0.0	0.0	0.0	0.0	0.0	2.8	3.6	4.9	6.6	7.6	8.8	9.4	9.8

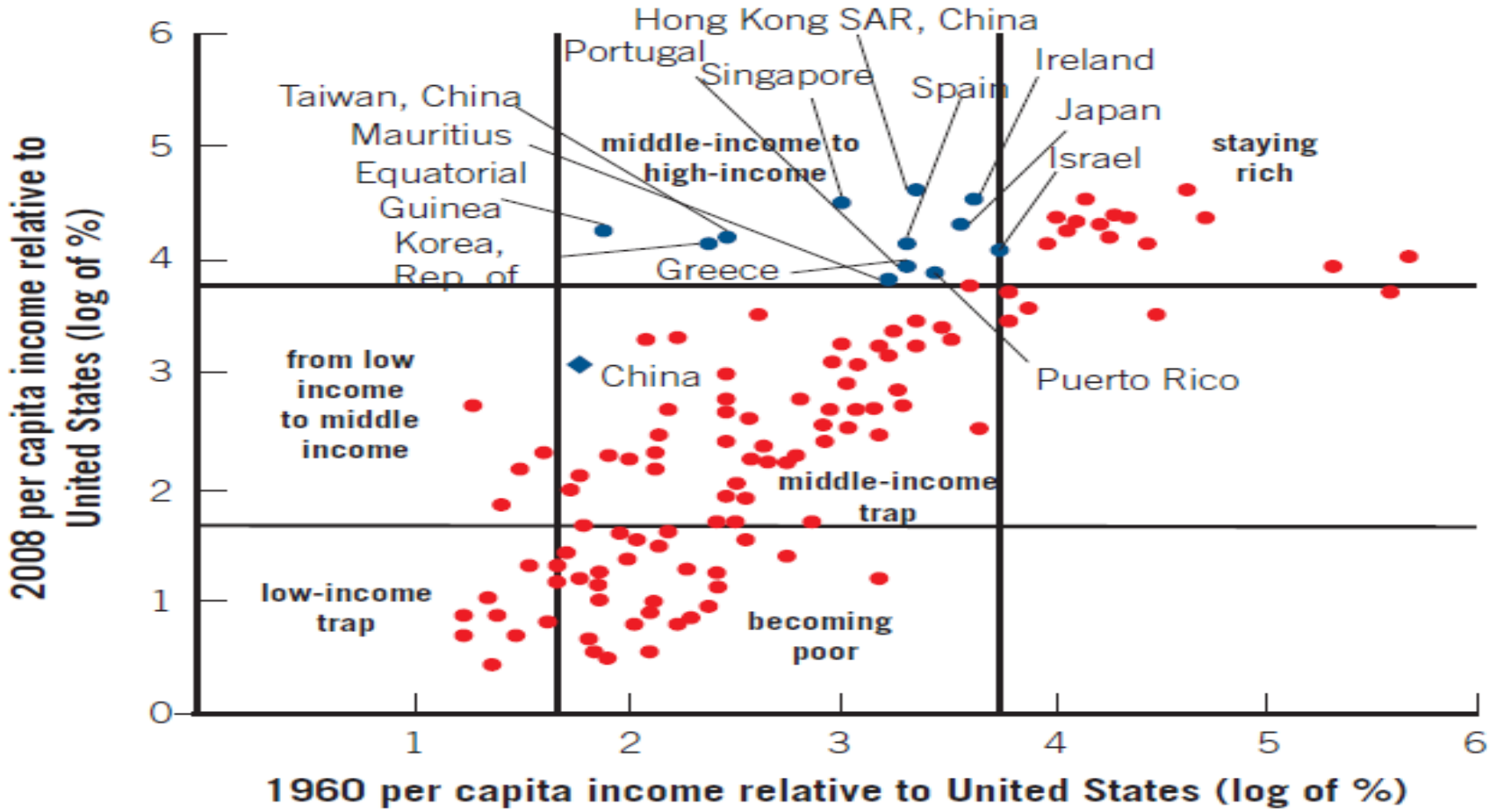
Mexico, Brazil, Chile, Argentina, South Africa, and Mauritius: Middle income Trap: Per capita Income less than 40% of the US => All the same trapped NIS:



Q: Who escaped the Middle income Trap: only 13, and How?

1) Periphery Europe +Israel: Greece, Portugal, Spain, Ireland, Israel
2) Japan + 4 E Asian Tigers: Korea; Taiwan, Hong Kong, Singapore
3) Others: an oil exporter (Equatorial Guinea), Puerto Rico, Mauritous

Figure 1. Per Capita Incomes Relative to the United States, 1960 and 2008



Source: World Bank 2012.

5 patent-citation variables to measure the NIS (Lee 2013): Basis for a composite index of NIS (Lee&Lee 2019, JEE)

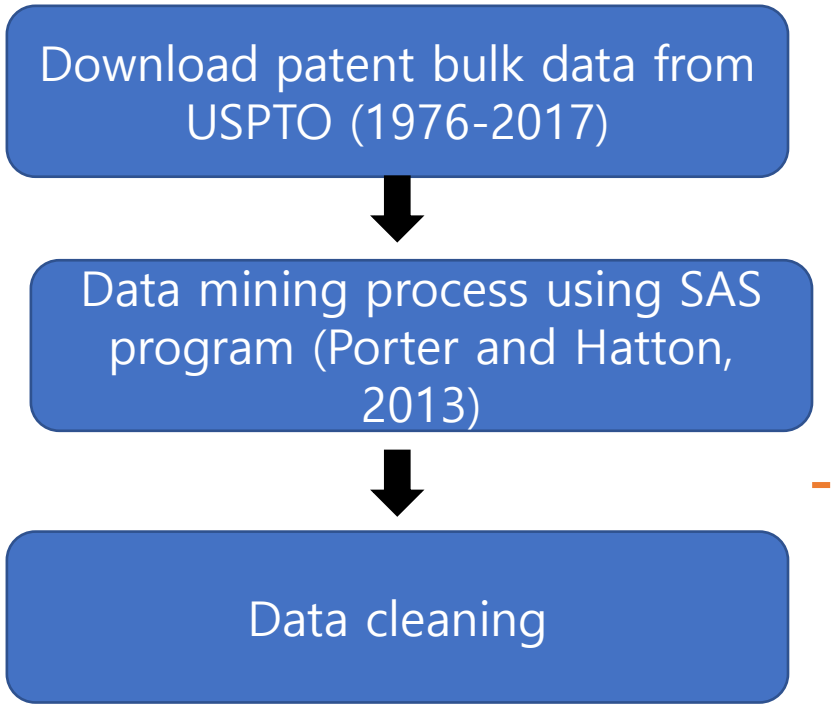
Localization of knowledge (Intra-national creation and diffusion) (vs. reliance on foreign sources)
Dispersed vs. Concentration = 1-HHI of knowledge creation (by assignees)
Short vs. long cycle technologies Specialization
Originality (high if citing and combining widely) (= Technological Convergence /combination)
Technological Diversification (Wide vs. Deep in patent portfolio)

=> Somewhat Narrow but close to the definition by Lundvall (about knowledge) also better in terms of homogenous dataset (US patents) over longer term

Data from USPTO;

Basically, inventor's information, ownership -> assignee's information

- Patent related data: from USPTO (Unites States Patent and Trademark Office)
- Information regarding patent: patent number, inventors' address (city, country), citation information, sector classification, etc.



NBER DB(1963-1993, 1976-2006),
Harvard Dataverse,
United States Patent Dataset (1926-2010)
U.S. Patent and citation Data
Based on USPTO patents

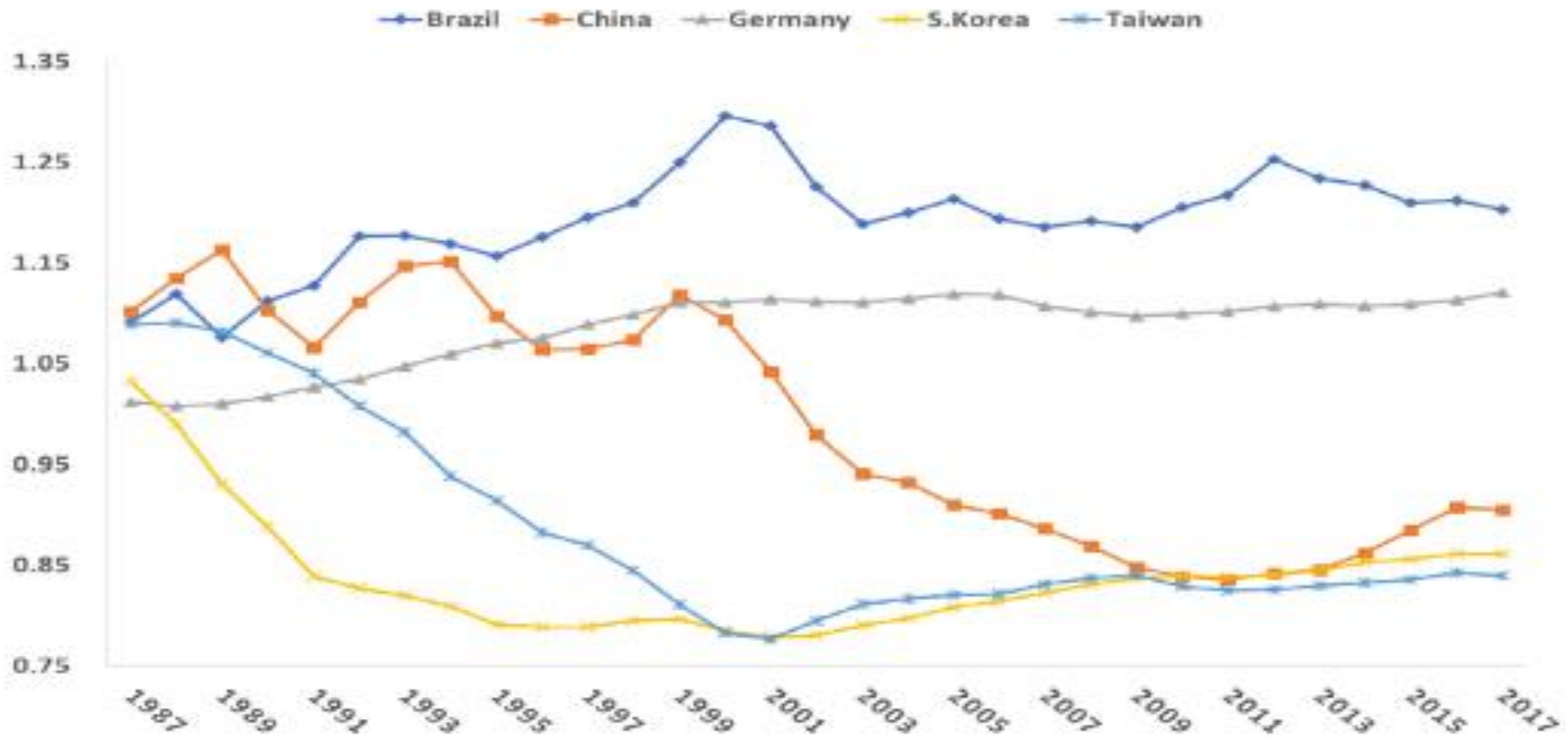
NIS Index of 45 economies, 2011~2015:
Lee & Lee (2019, JEE), NIS robust than Econ. Complexity to predict Econ Growth

Country	Localization	Tech Diversif'n	Originality	Relative cycle time	Decentral'n 1-HHI	Index of NIS-5	Rank of NIS5
Japan	0.407	0.866	0.354	0.942	0.980	3.566	1
United States	0.246	0.937	0.503	1.005	0.994	3.495	2
Germany	0.140	0.844	0.455	1.106	0.984	3.147	3
France	0.111	0.735	0.402	1.083	0.975	2.873	4
United Kingdom	0.070	0.687	0.450	1.157	0.993	2.855	5
Italy	0.090	0.611	0.408	1.163	0.981	2.763	6
Australia	0.134	0.469	0.466	1.176	0.923	2.742	7
Switzerland	0.042	0.657	0.434	1.159	0.984	2.730	8
Canada	0.065	0.671	0.486	1.014	0.935	2.709	9
Taiwan	0.129	0.674	0.331	0.828	0.971	2.575	10
Netherlands	0.075	0.582	0.434	1.041	0.903	2.564	11
Israel	0.066	0.431	0.498	1.044	0.990	2.551	12
South Korea	0.137	0.705	0.339	0.846	0.854	2.533	13
Denmark	0.081	0.374	0.429	1.169	0.971	2.516	14
Norway	0.080	0.268	0.482	1.200	0.985	2.503	15
Austria	0.076	0.405	0.422	1.133	0.967	2.496	16
Sweden	0.098	0.568	0.390	0.992	0.824	2.435	17
Belgium	0.065	0.378	0.418	1.130	0.955	2.421	18
China	0.048	0.643	0.332	0.854	0.944	2.343	19
New Zealand	0.043	0.172	0.481	1.251	0.976	2.341	20
Spain	0.044	0.324	0.400	1.107	0.986	2.308	21

Country	Localization	Diversif'n	Originality	Relative cycle time	1-HHI	NIS5	Rank of NIS5
Finland	0.095	0.418	0.426	0.976	0.770	2.249	22
South Africa	0.072	0.116	0.424	1.231	0.959	2.249	23
Brazil	0.022	0.158	0.390	1.237	0.957	2.134	24
Mexico	0.014	0.096	0.485	1.216	0.933	2.129	25
Hong Kong	0.037	0.289	0.388	0.978	0.965	2.126	26
Ireland	0.023	0.241	0.465	0.993	0.929	2.109	27
Singapore	0.037	0.323	0.437	0.889	0.915	2.106	28
India	0.028	0.243	0.371	1.057	0.969	2.097	29
Luxembourg	0.007	0.221	0.472	1.032	0.928	2.088	30
Poland	0.069	0.074	0.369	1.156	0.952	2.072	31
Saudi Arabia	0.020	0.191	0.467	1.130	0.774	1.999	32
Malaysia	0.035	0.084	0.399	1.129	0.917	1.982	33
Chile	0.014	0.042	0.426	1.175	0.939	1.976	34
Portugal	0.032	0.045	0.418	1.106	0.932	1.956	35
Hungary	0.033	0.049	0.384	1.116	0.939	1.934	36
Argentina	0.041	0.028	0.392	1.135	0.909	1.926	37
Russia	0.039	0.102	0.423	0.934	0.889	1.871	38
Czech Republic	0.018	0.056	0.332	1.110	0.945	1.845	39
Thailand	0.009	0.031	0.467	1.107	0.824	1.837	40
Slovenia	0.014	0.038	0.335	1.272	0.831	1.822	41
Greece	0.016	0.031	0.327	1.179	0.870	1.781	42
Iceland	0.039	0.038	0.420	1.300	0.563	1.735	43
Indonesia	0.000	0.006	0.445	1.361	0.442	1.562	44
Philippines	0.002	0.011	0.465	1.121	0.547	1.528	45

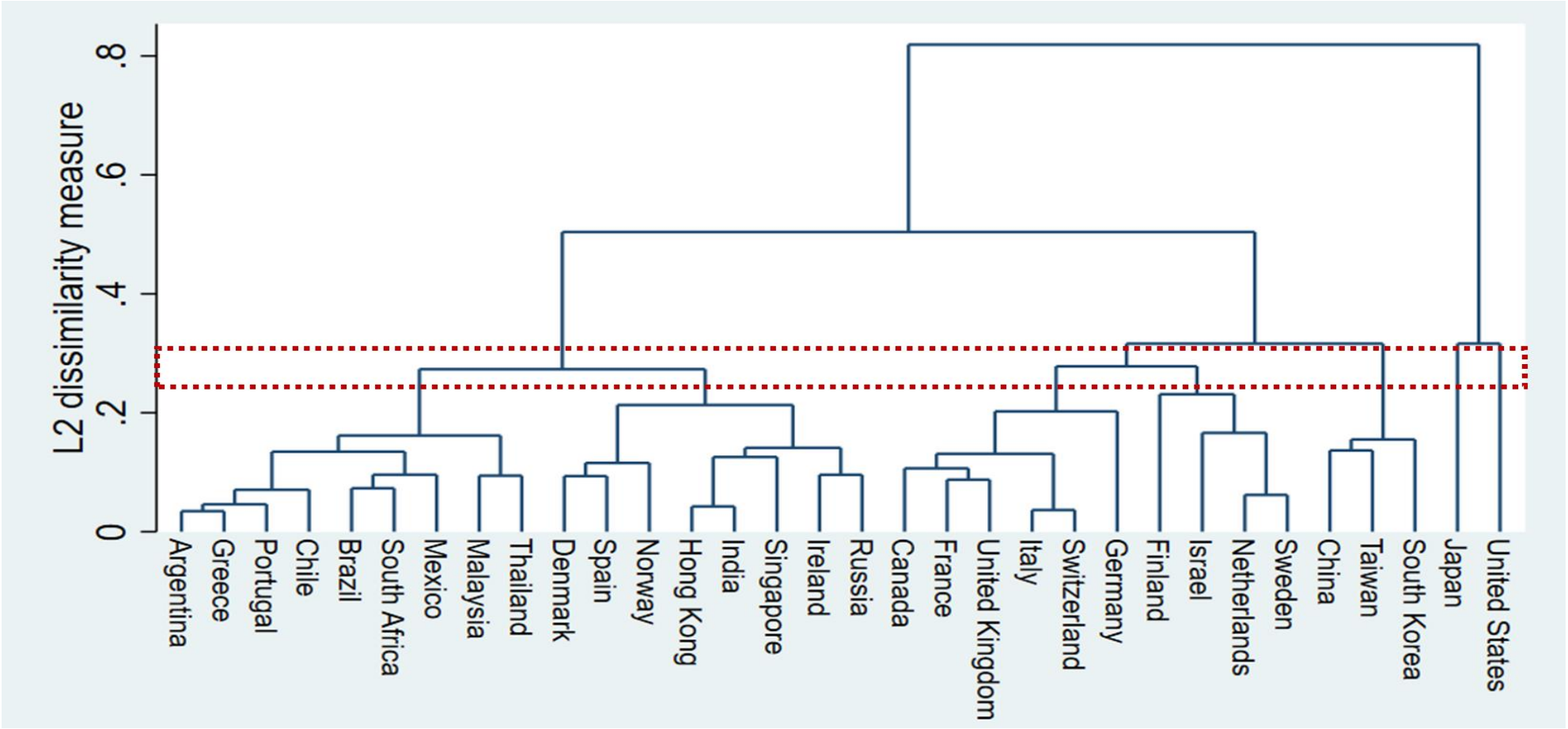
Sectoral Specialization in CTT Matter:

Eg) Brazil: long CTT = Mid Inc Trap; Korea = short to long CTT detour



Measure of CTT (cycle time of technology)
= time lag between the application years of the citing and cited patent.
= speed of depreciation of technologies
→ Korea & and Taiwan specialized in short CTT sectors during their catching-up period.

The Cluster Analysis using the 32 Economies to identify NIS types (cf VoC)



1) Balanced and Mature NIS (6): Canada, Germany, France, Italy, Switzerland, and the United Kingdom.
2) Balanced, med cycle catching-up NIS (8): Ireland, Spain, Hong Kong, Singapore, India, Russia
3) Imbalanced, short-cycle, Catching-up NIS (3): China, South Korea, and Taiwan.
4) Imbalanced, long cycle, Trapped (9): Argentina, Brazil, Chile, Malaysia, Mexico, S. Africa, Thailand, Greece, Portugal

Part A: Two Balanced vs. Two Imbalanced NIS

Balanced, med cycle, catching < Balanced, Mature

Imbalanced, long cycle, trapped vs. Imbalanced, short cycle, & catching up

1) Balanced and Mature NIS (6): Canada, Germany, France, Italy, Switzerland, and the United Kingdom.
2) Balanced, med cycle (catchup) NIS (8): Singapore. Ireland, Spain, Hong Kong, India, Russia
3) Imbalanced, short cycle, Catching-up NIS (3): China, South Korea, and Taiwan.
4) Imbalanced, long cycle, Trapped NIS (7): Argentina, Brazil, Chile, Malaysia, Mexico, South Africa, and Thailand.

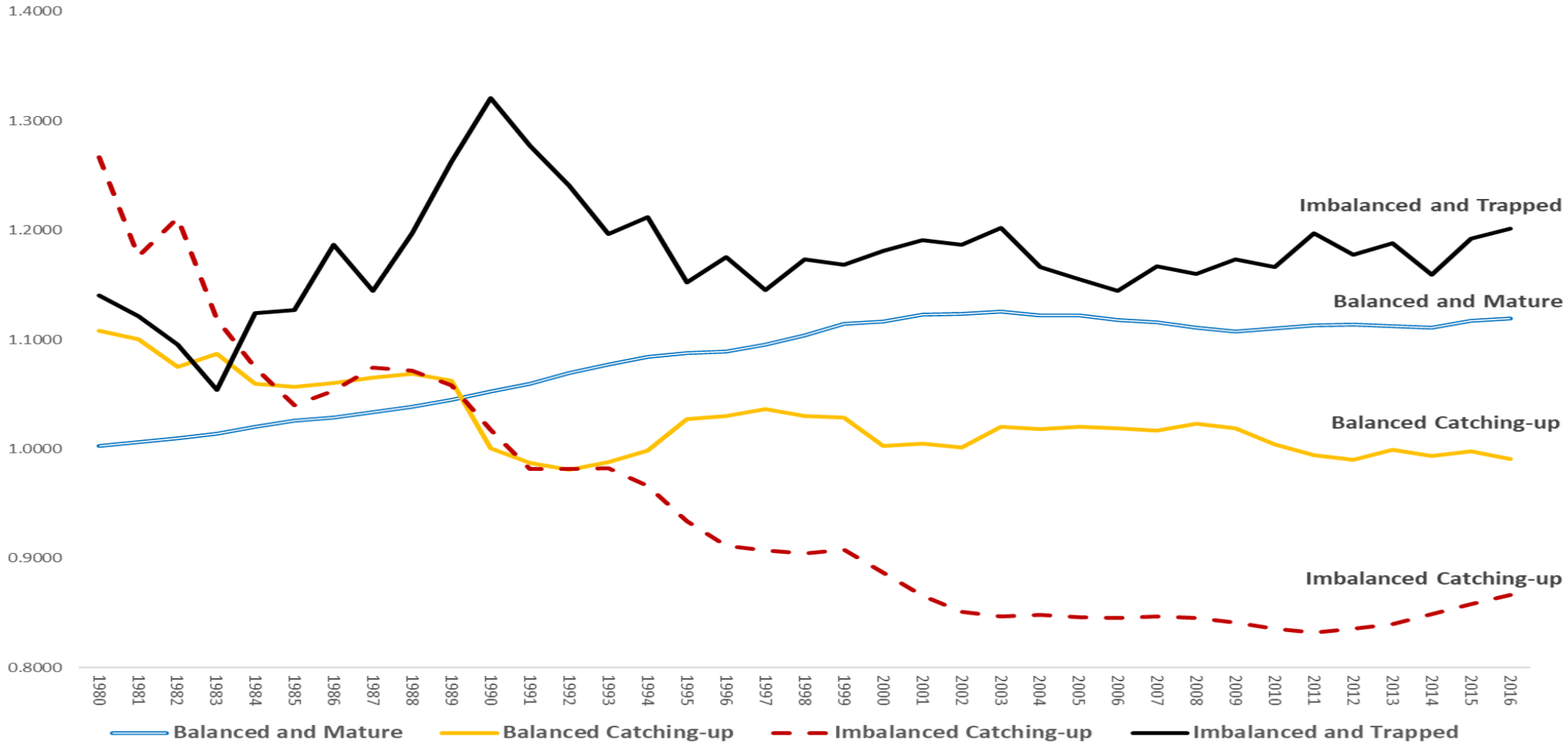
Relative Cycle Time of Technologies: short cycle, catching up NIS

Getting into short cycles (less entry barrier) sectors

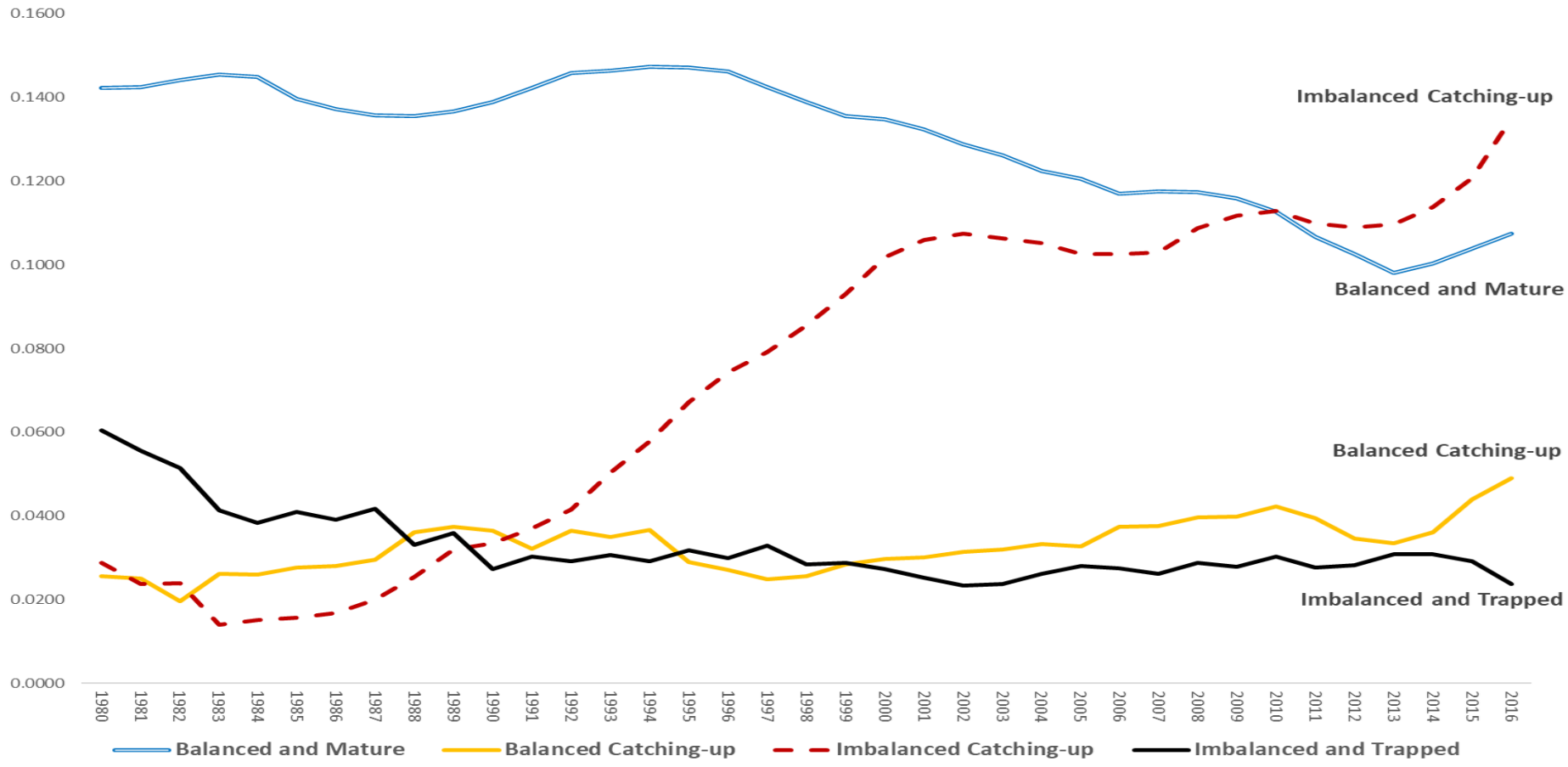
-> higher/quicker localization (less need to rely on incumbents)

-> more tech. diversification by keep entering newly emerging classes

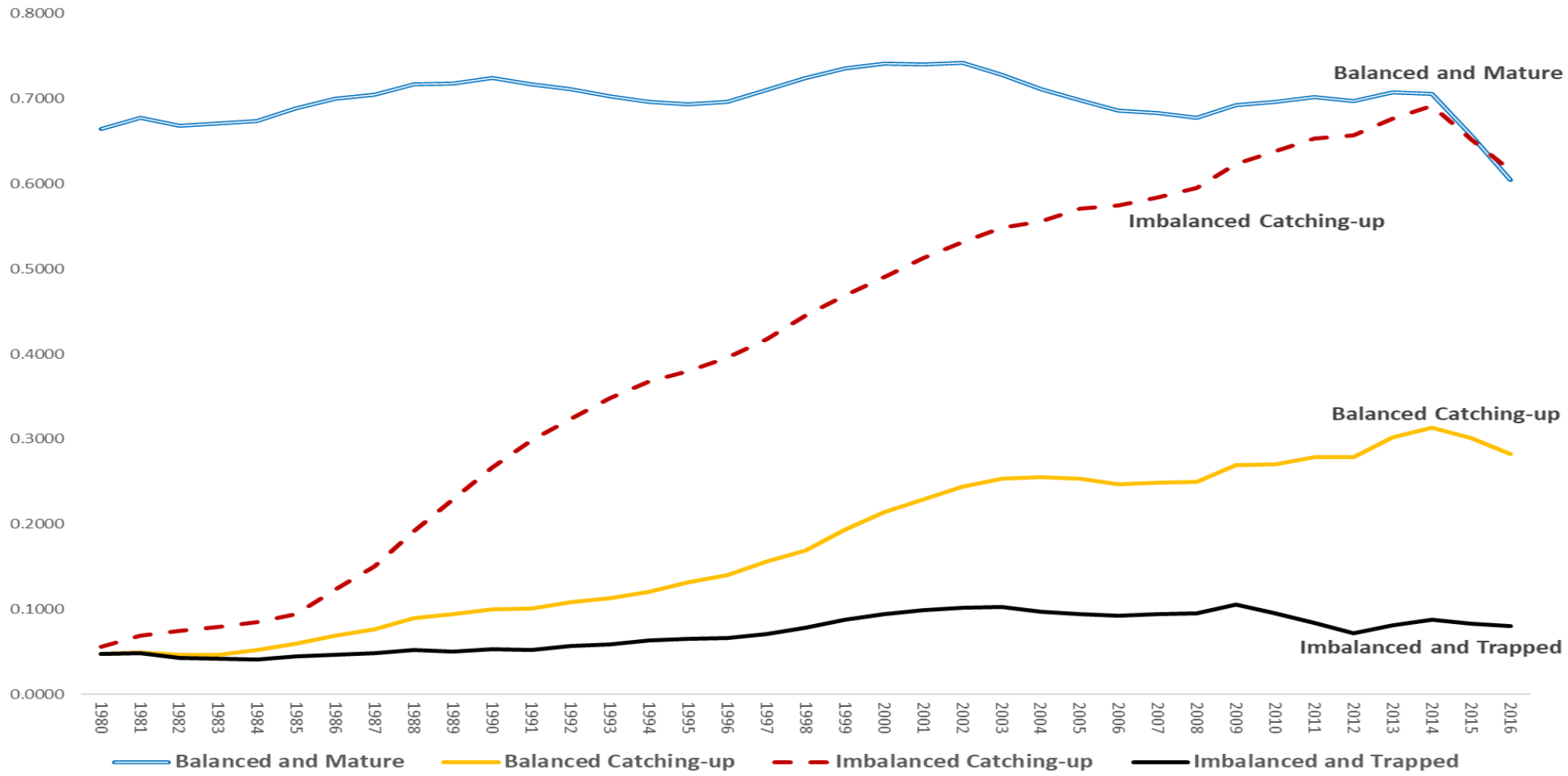
➔ A Detour from short to long cycles in Korea, Taiwan, China



Dynamic Change of the NIS Variables, Knowledge Localization



Dynamic Change of the NIS Variables: Technological Diversification



Dynamic Evolution of the NIS over time (Cluster Analysis) : Korea = Used to be in mixed group but created catching up NIS; joined by China

Group	Group 1	Group 2	Gr. 3	Group 4	Group 5	Group 6	Group 7	Group 8	Gr. 9
1984-91	Argentina, Brazil, China, Denmark, Finland, Hong Kong, India, Ireland, Israel, Malaysia, Mexico, Norway, Singapore, S. Africa, South Korea, Spain, Taiwan	Chile, Greece, Portugal	Thailand				Canada, France, Germany, Italy, UK, Swiss, Sweden, Netherlands	Japan	USA
1992-99	Argentina, Brazil, Chile, China, Denmark, Finland, Hong Kong, Greece, Israel, Ireland, India, Mexico, Malaysia, Norway, Portugal, Russia, S. Africa, Spain, Thailand	Chile, Portugal		Singapore	South Korea		Canada, France, Germany, Italy, UK, Swiss, Sweden, Netherlands, Taiwan	Japan	USA
2000-07	Argentina, Brazil, Chile, Denmark, Hong Kong, Greece, Mexico, Norway, Portugal, Russia, South Africa, Spain, Thailand			Singapore, Ireland, India Malaysia, China	South Korea, Taiwan		Canada, France, Germany, Italy, UK, Swiss, Sweden, Netherlands, Finland, Israel,	Japan	USA
2008-15	Argentina, Brazil, Chile, Malaysia, Mexico, South Africa, Thailand, Greece, Portugal			Singapore, Ireland, India, Spain, H.Kong, Denmark, Norway, Russia	South Korea, Taiwan, China	Finland, Sweden, Israel, Netherlands	Canada, France, Germany, Italy, UK, Swiss	Japan	USA

From NIS Types to Economic Growth: two catching up vs trapped NIS

Dependent var.: average GDP per capita growth by periods	GLS: Pooled estimation with dummies				GLS: Pooled estimation with dummies	
	Model (3)		Model (4)		Model (6)	
	Periods: 1983-2015		Periods: 1992-2015		Periods: 1992-2015	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
ln(Initial GDP)	-0.0086***	(-4.20)	-0.0081***	(-4.00)	-0.016***	(-5.88)
Population Growth Rate	-0.31**	(-2.01)	-0.097	(-0.51)	-0.11	(-0.58)
Fixed Investment Rate	0.13***	(4.94)	0.10***	(3.52)	0.12***	(4.29)
Enrollment Rate Secondary	-0.0015	(-0.15)	-0.000029	(-0.003)	0.0069	(0.66)
Balanced and Mature NIS						
Balanced Catching-up Group	0.018***	(3.33)	0.014**	(2.39)	0.020***	(3.23)
Other Balanced Group	0.0046*	(1.72)	0.0049	(1.38)	0.0030	(0.88)
Imbalanced Catching-up NIS	0.030***	(4.14)	0.037***	(4.54)	0.023***	(5.61)
Imbalanced and Trapped NIS	**-0.0056**	**(-1.59)**	**-0.0048**	**(-1.41)**	**-0.0062***	**(-1.87)**
Constant	0.080***	(4.48)	0.076***	(4.30)	0.15***	(5.64)
Observations	230		177		177	
Adjusted R-squared						
Wald chi-squared	423.66***		213.51***		242.66***	

Summary: NIS to Economic Growth beyond MIT

1) Variety of NIS <= similar to Variety of Capitalism:

-- Confirms correspondence between diverse NIS types and catching-up/falling behind performance.

-- Balanced NIS (mature or catching-up) vs. Imbalanced (catching-up vs. Trapped)

2) Imbalanced, Short cycle, Catching-up NIS in E Asia = specialization into short cycle Tech.; increased localization & diversification;

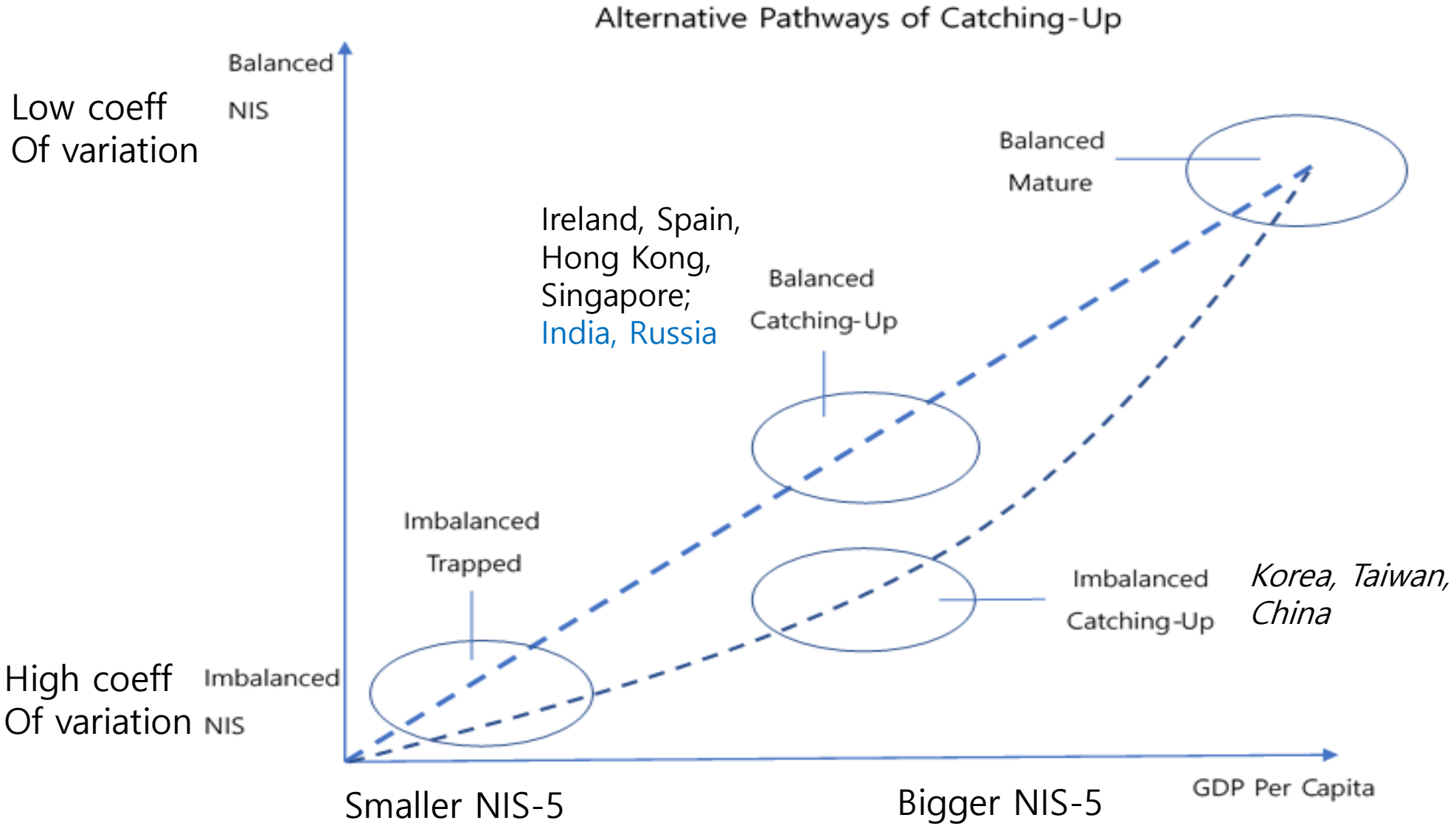
-- Getting into short cycles -> higher localization (less need to rely on incumbents) -> tech. diversification by keep entering newly emerging classes

-- These catching up economies all used to be the same type as other MICs but they created their own catching up NIS since the 1990s

3) Balanced, med cycle, Catching-up NIS = alternative to E Asian Path; Spain, Ireland -> India/Russia in the NIS : promising future: Turkey ? common pattern of diversification = manuf + services

Balanced vs. Imbalanced Development: Nurkse (1953) vs Hirschman (1958):

balance between agriculture and manuf => between manuf and services & balances in NIS



Varieties of Regional Innovation Systems (RIS) and Catch-up by Latecomers

1) RIS of Taipei, Shenzhen, and Penang in Asia (Kim & Lee, TFSC 2022)

2) Cluster Analysis RIS of 30 cities/regions around world)

Introduction: Why from NIS to RIS and How

* National innovation system (NIS)

- a key concepts in Schumpeterian economics (Freeman, 1987; Lundvall, 1992; Nelson, 1993).
- differences in NIS ➔ differences in innovation performance ➔ economic growth.

- Question? Uneven distribution of innovations even in the same nation? (Asheim et al., 2019: 1)

- To see what elements (dimension) of innovation is binding at regional level development beyond the middle-income stage of development where innovation becomes a more binding factors than prices or costs at the earlier stages (Mazzoleni and Nelson, 2007; Lee 2013).

- Patent-citations based measurement and analysis of RIS:

Literature: Regional Innovation Systems: Less quantitative analysis (typology/regressions)

- Various RIS studies explaining a typology and dynamic change of RIS and showing a variety of criteria and perspectives on the RIS. (Asheim, 1998; Asheim et al., 2019; Asheim and Gertler, 2006; Cooke, 2005, 2001, 1998): ***Qualitative measurement***
- Some quantitative approaches have been used to study the efficiency of different kinds of regional innovation systems (Fritsch and Slavtchev, 2011; Zabala-Iturriagagoitia et al., 2007).
- Lack of researches of RIS typology for emerging economies as well as generalized typology covering various regions over the world.

- ***Goal*** Suggest new RIS typology with RIS variables referring to the NIS variables in Lee (2013), Lee and Lee (2019), and Lee et al. (2021).
  - Especially in terms of catching-up

A key aspect of Catch-up RIS = Localization of knowledge & ownership

- Peripheral /immature RIS = heavy reliance on external knowledge given its lack of indigenous knowledge base, and low level of regional embeddedness (Rodriguez et al. 2014; Asheim et al. 2019: Park & Markusen 1995; Hassink 2001).
- Latecomers' reliance on foreign knowledge: latecomer economies tend to achieve economic growth by relying on FDI and learning from MNCs (Bernardes and Albuquerque, 2003; Lebdioui et al 2021; Amsden and Chu 2003).

=> consistent with the NIS of emerging or catching-up economies (Lee 2013; Lee et al. 2021a).

- From low level of knowledge localization at the early stage to an increasing trend.

- The importance of acquiring indigenous technological capabilities or knowledge ownership is emphasized when it comes to catching up or at the later stage of development (Mazzoleni and Nelson 2007; Lebdioui et al. 2020)

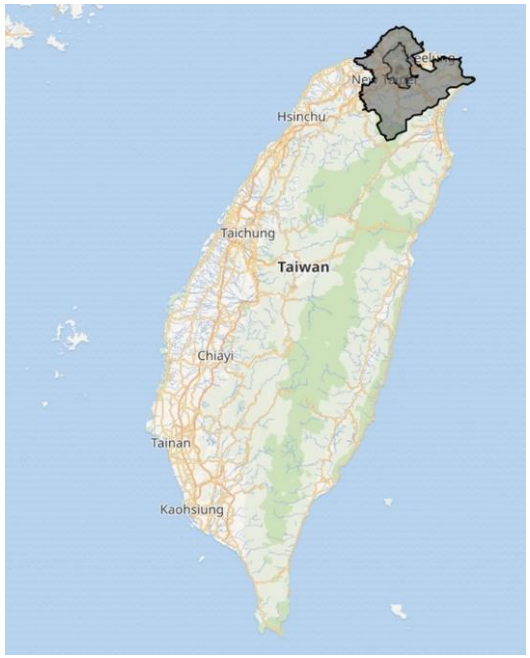
=> introduce a variable representing ownership of knowledge

A) ownership matter: MNC dominance-> keep relying on their home R&D
-> no local creation and diffusion of knowledge

Eg) Different speed of Catching up in same short cycle cluster. Q) why?

Thee RIS: fast vs. slow catching up: despite a common initial conditions

Taipei

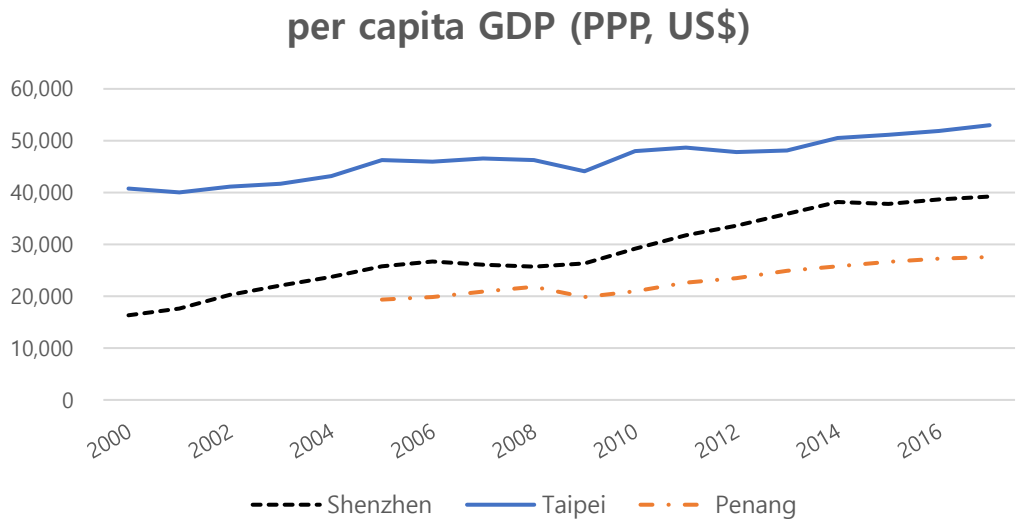


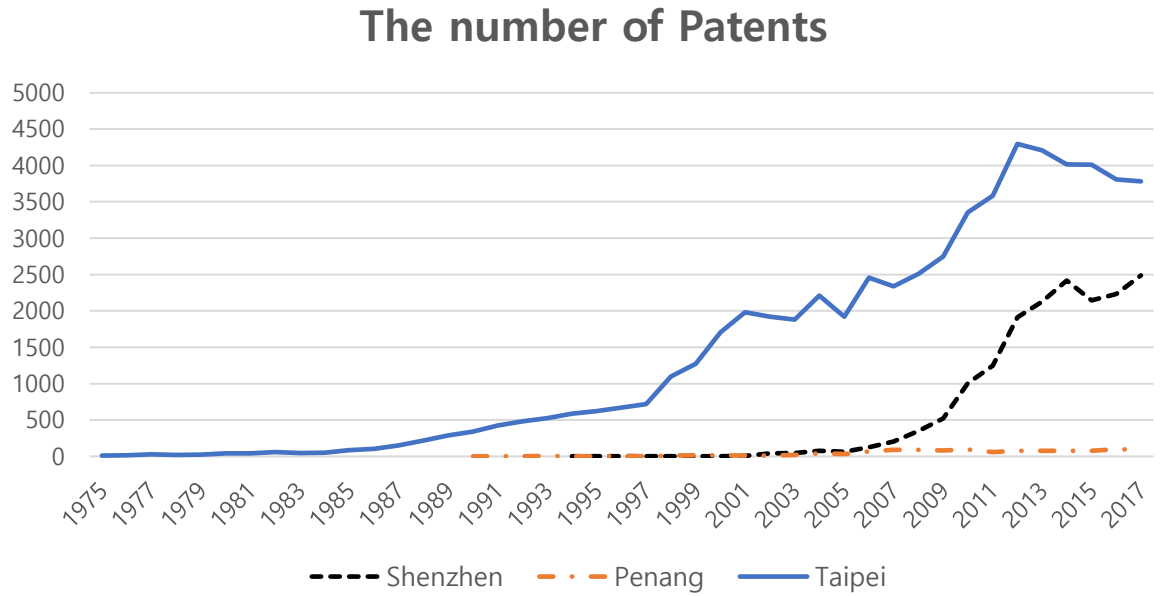
Shenzhen

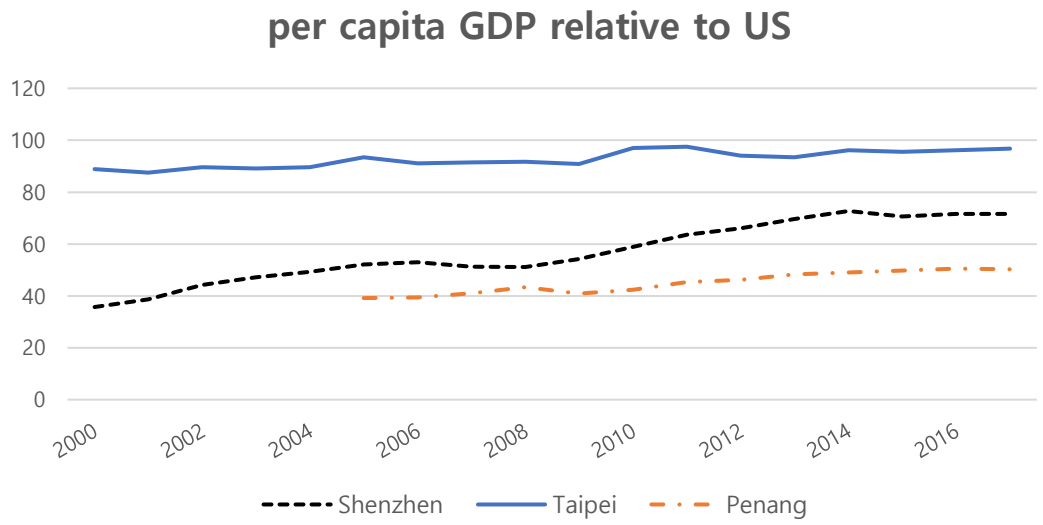
Penang

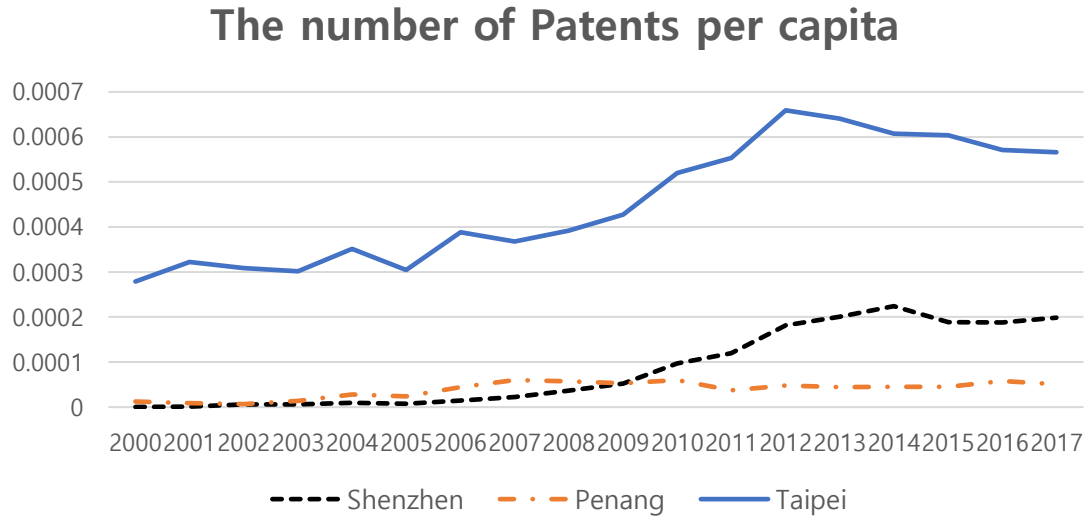
- share common take-off by promoting foreign direct investment (FDI) by MNCs; industrial parks,
  - Export Processing Zones (EPZs) in Taipei in 1960s,
  - the Special Economic Zones in Shenzhen in 1980,
  - the Free Industrial Zone in Penang in1972 (Hsu, 2005; UNDP, 2006).
- economic performance and catching up show some variance: esp. Shenzhen and Penang.

Different speed of Catching up in same short cycle cluster









Hypotheses 1: decreasing role of foreign knowledge;
=> Intra-region, Inter-region, Inter-national knowledge diffusion

- Intra-regionalization: how many patents invented in region x cite patents invented in its own region.
- Inter-regionalization: how many patents invented in a region cite patents invented in other regions in the same nation
- Internationalization: how many patents invented in region x cite patents invented in other countries.
- The more advanced economies, the less dependent on foreign knowledge
  (⇔ high intra-regionalization, low internationalization).

Hypo: Taipei would show a high and increasing level of intra-regional knowledge localization and, at the same time, a low and decreasing level of internationalization (less relying on foreign knowledge).

- Shenzhen:= to be similar to Taipei. Cf) Penang : no such trend

- Inter-regionalization: a more advanced or catching up region would show a high or increasing level of inter-regionalization (a high or increasing citations to patents by other regions).

Three measures: (Jaffe et al., 1993; Lee and Yoon, 2010; Lee, 2013)

- Intra-regionalization.
  - $Intra-regionalization_{xt} = \frac{n_{xxt}}{n_{xt}}$,

  : the ratio of region x citing its own region invented patents.

- Inter-regionalization
  - $Inter-regionalization_{xt} = \frac{n_{xx't}}{n_{xt}}$, *where* $x+x' = c$, *and* x *means a region located in country* c.

  : the ratio of citation made from patents invented in region x to patents invented in other regions than region x (but in the same country).

- Internationalization
  - $Internationalization_{xt} = \frac{n_{xdt}}{n_{xt}}$, *where* $\boldsymbol{x}$ *means a region located in country* $\boldsymbol{c}$ *and* $\boldsymbol{d}$ *means other countries than country* $\boldsymbol{c}$.

  : the ratio of citations made by region x to other countries (d)

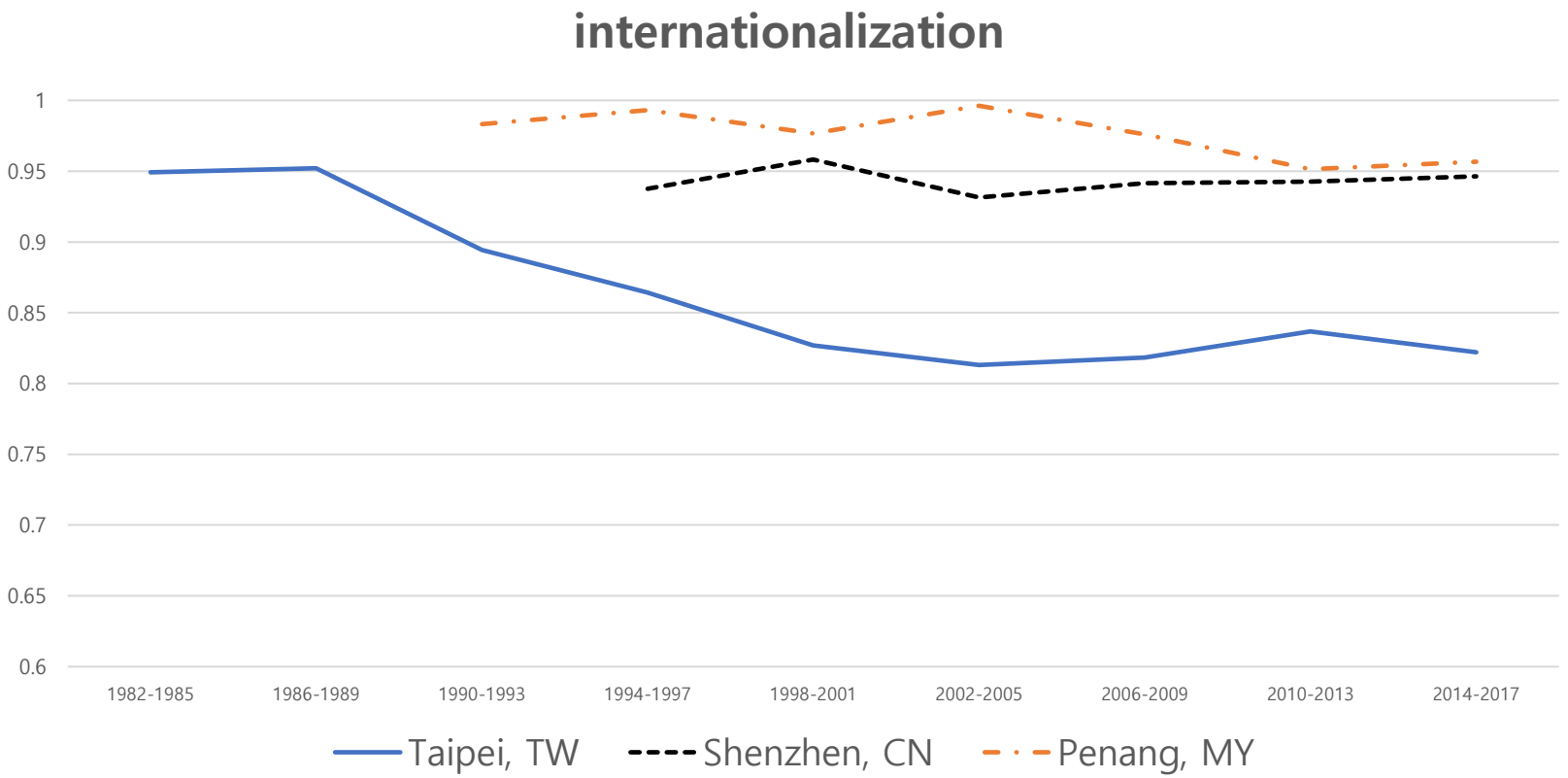
n_{xxt} : the number of citations made to region x's patents by region x's granted in year t .

n_{xt} : the number of all citations made by region x's patents granted in year t

$n_{xx't}$: the number of citations made from patents invented in region x granted in year t to patents invented in region x' granted in year t, where region x' means other regions than region x and is located into the same country with region x.

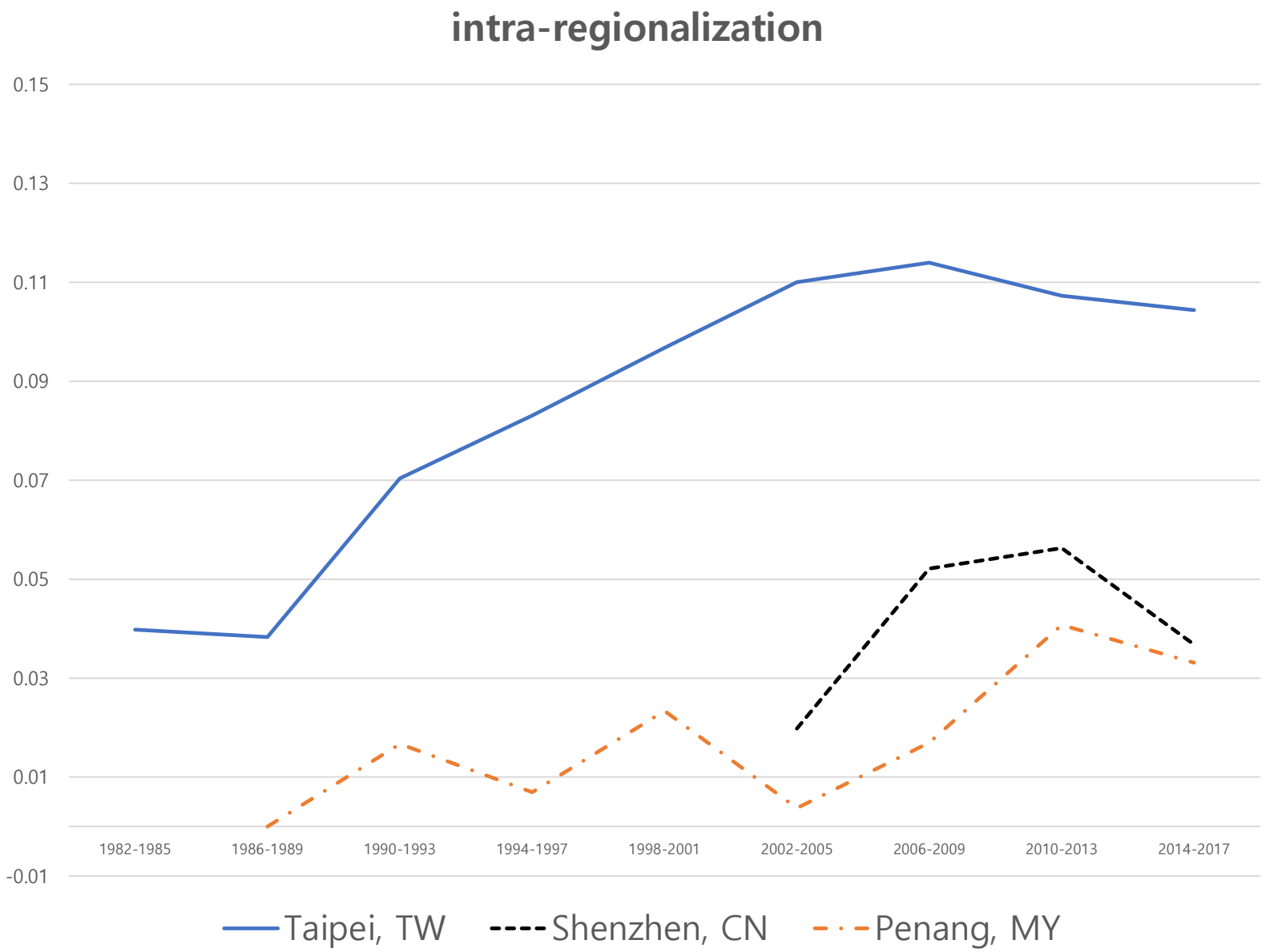
n_{xdt} : the number of citations made to country d by region x's patents granted in year t, where country d is different from the country that region x belongs to.

Order of Internationalization => Opposite to level of Per capita Income

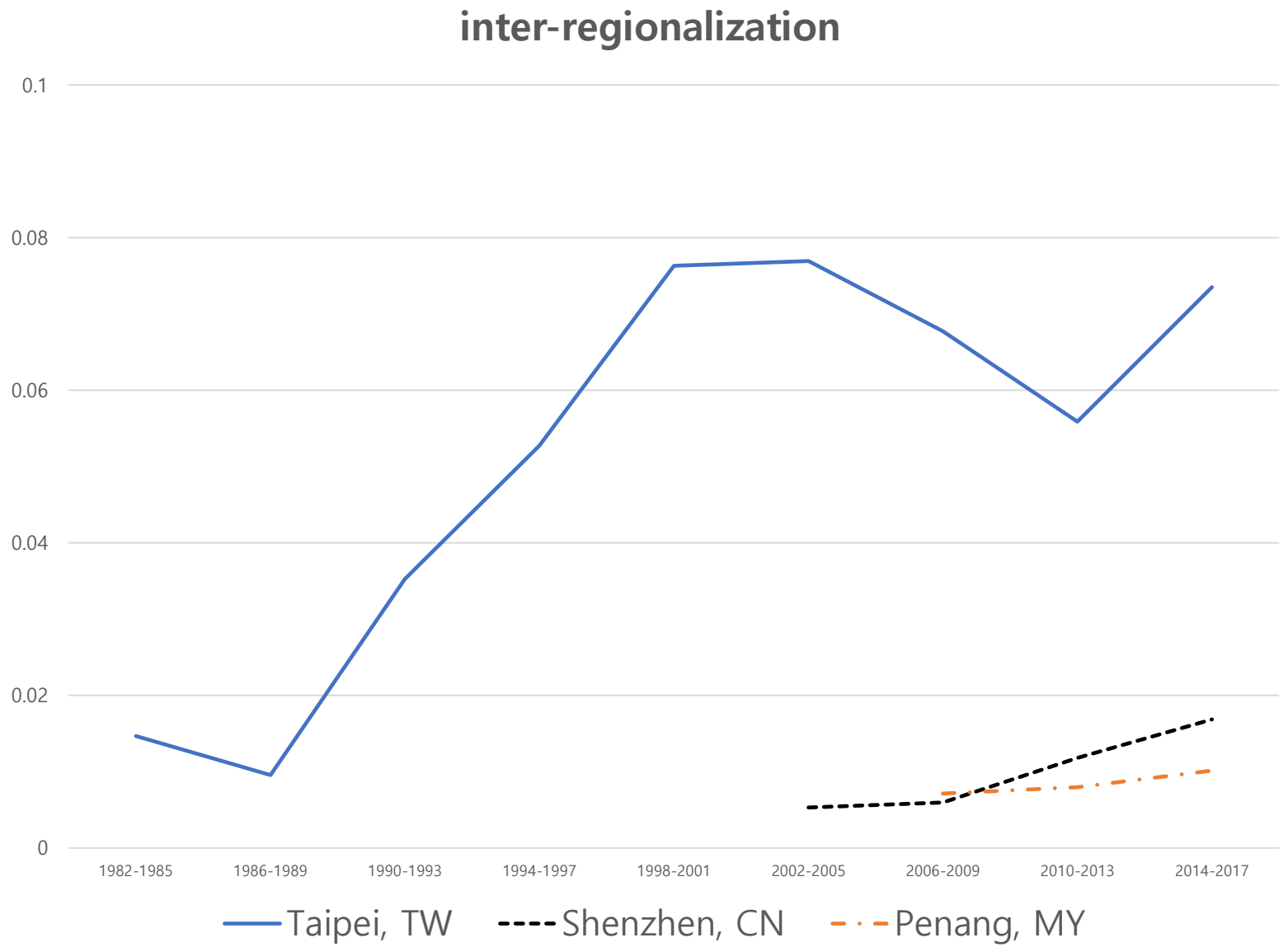


- **Taipei** shows a clear trend of reducing the internationalization or the reliance on foreign patents, which reflects the enhancement of its own indigenous technological capabilities and of the RIS.
  - 95% in the early 1980s to less than 82% in the early 2000s despite slight increase in 2010s
- **Shenzhen or Penang** with level of internationalization still higher than 90%.
- Shenzhen's level is lower than that of Penang,

Intra-regionalization



Inter-regionalization



Hypotheses 2: role of local/foreign ownership of patents

- Relying on foreign-owned knowledge (patents) is not enough to sustain the catch-up up to the later stage because foreign firms would become increasingly reluctant to transfer or sell their technologies to latecomers gettting close to the frontier (Lebdioui et al 2021: Lee 2005).
  - Amsden and Chu (2003) : Taiwan = increasing locally-owned firms.
  - Mazzoleni and Nelson (2007) : South Korea and Taiwan, successfully catching-up countries, as acquiring indigenous technological capability.

⇒ Hypo: Taipei has a high level of local ownership of patents (high share of patents filed by locally-owned firms);

⇒ Shenzhen : a trend of increasing share of locally-owned patents, compared to Penang.

Hypotheses 3: high originality from foreign ownership

- Originality (Hall et al. (2001; Trajtenberg et al. (1997) = degree that an innovation (patent) combines knowledge from diverse fields.
  - = a degree of knowledge convergence and combination

NIS: Originality tend to be high in advanced economies but not that high in catching up economies;
no robust relationship between high originality and economic growth of countries (Lee 2013: ch.3).

- If a region's economy and innovation is dominated by foreign MNCs from advanced economies, its level of originality would be higher

- **Hypo: Penang with continuing dominance by MNCs** would show a high level of originality than Taipei or Shenzhen as these latter two regions are now increasingly dominated by indigenous firms..

Hypo 2.3: Local firm ownership/Originality

3. Local firm ownership on knowledge : Indigenous knowledge

$$Local\ ownership = \frac{N_{cxt}}{N_{xt}},$$

N_{cxt} : the number of patents invented in a region x and assigned to a firm with its nationality in the host country c.

N_{xt} : the total number of patents assigned to any firms invented in a region with the first inventor address located in region x, granted in time t.

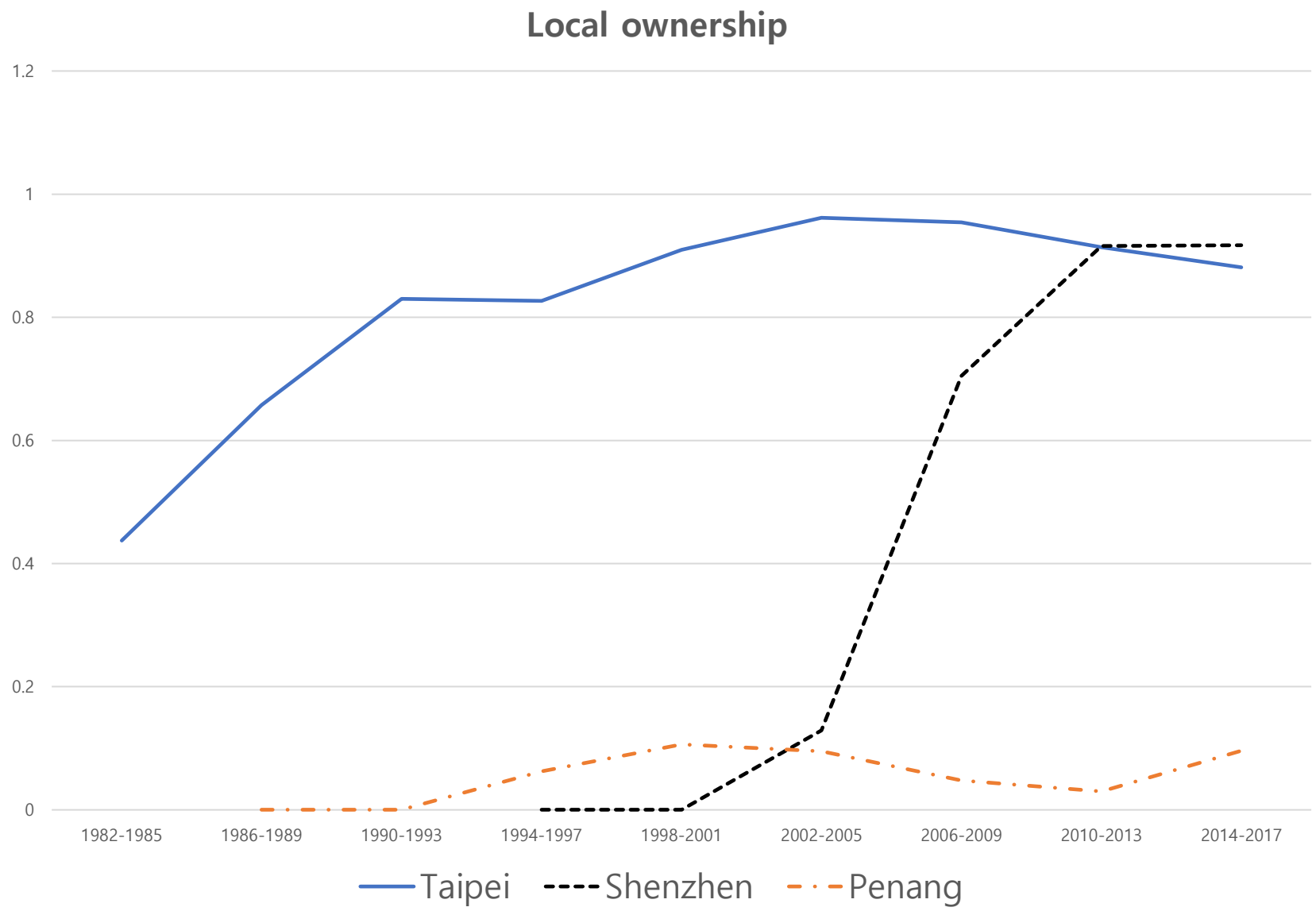
4. Originality (Hall et al., 2001; Trajtenber et al., 1997)
: how many various fields(classes) of knowledge are used, and thus cited to invent a patent.

$$Originality_i = 1 - \sum_{k=1}^{N_i} \left(\frac{NCITED_{ik}}{NCITED_i} \right)^2,$$

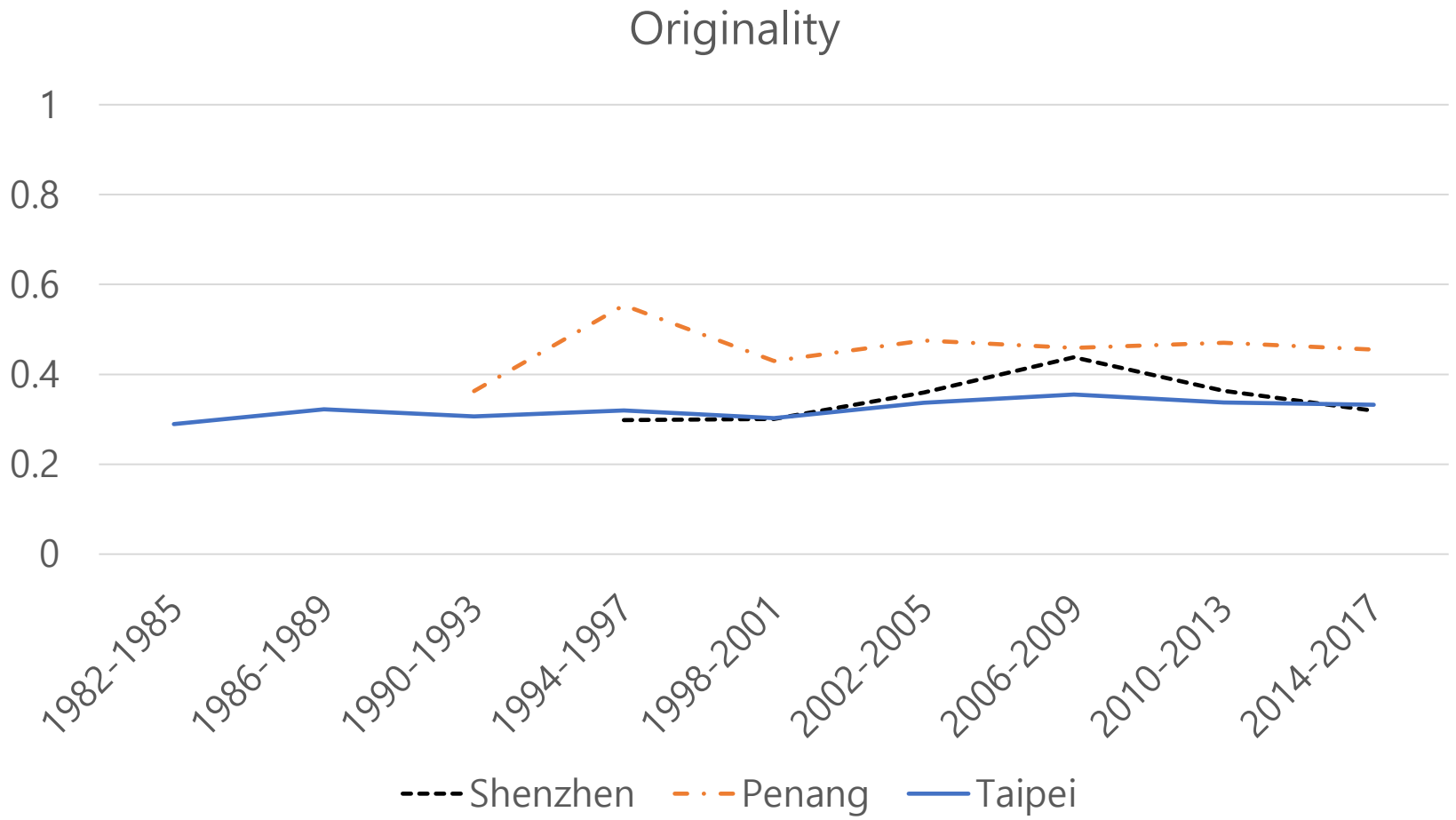
where k is patent class, $NCITED_{ik}$ is the number of citations made by the patent i to patents belonging to patent class k, and $NCITED_i$ is the total number of citations made by patent i.

- To transform this variable into a regional level variable, after calculating the originality of each patent, we average the values of originality over all the invented patents in a region.

Local firm ownership of knowledge: catching up Shenzhen

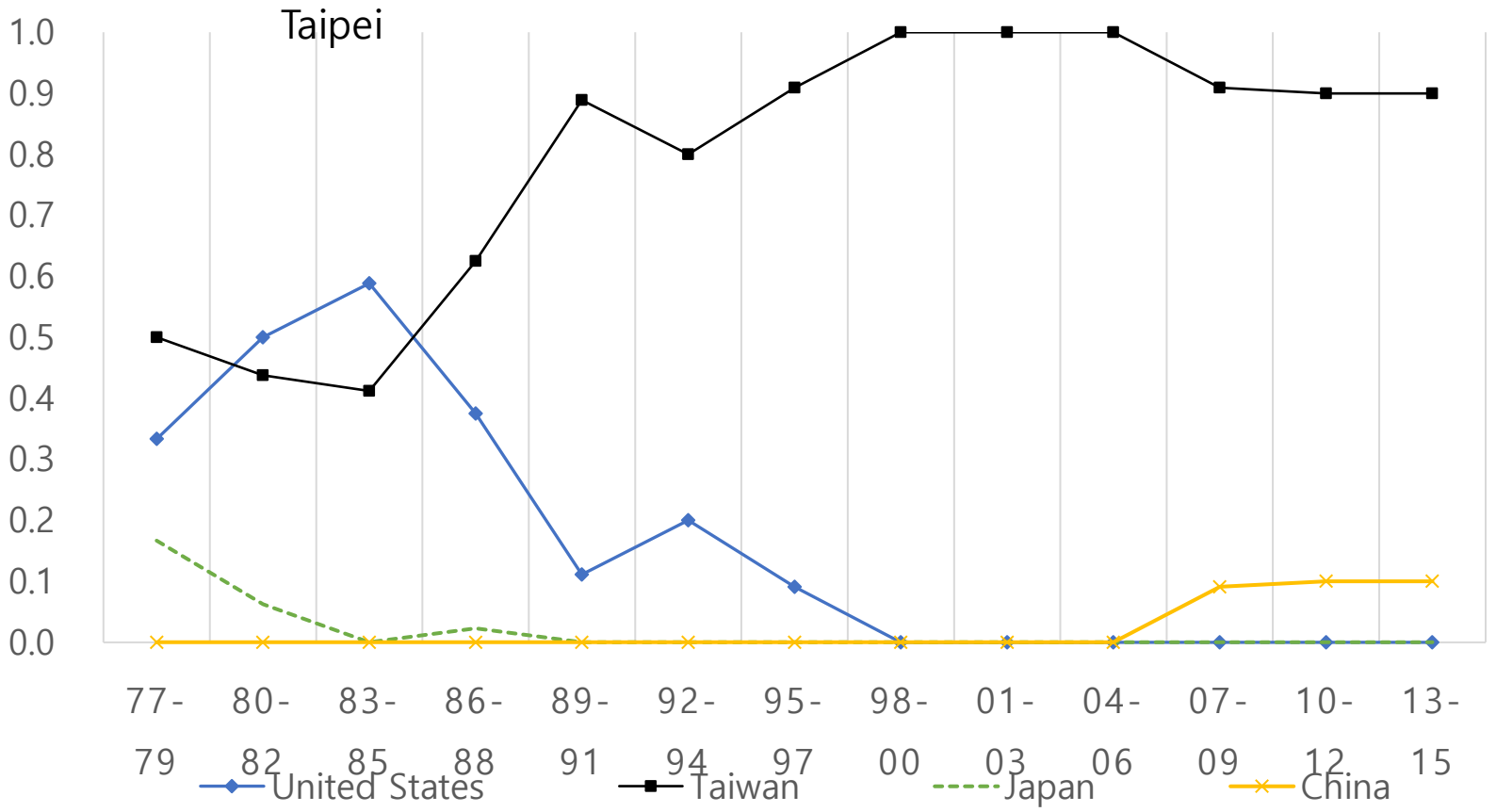


Originality; highest in Penang with foreign ownership



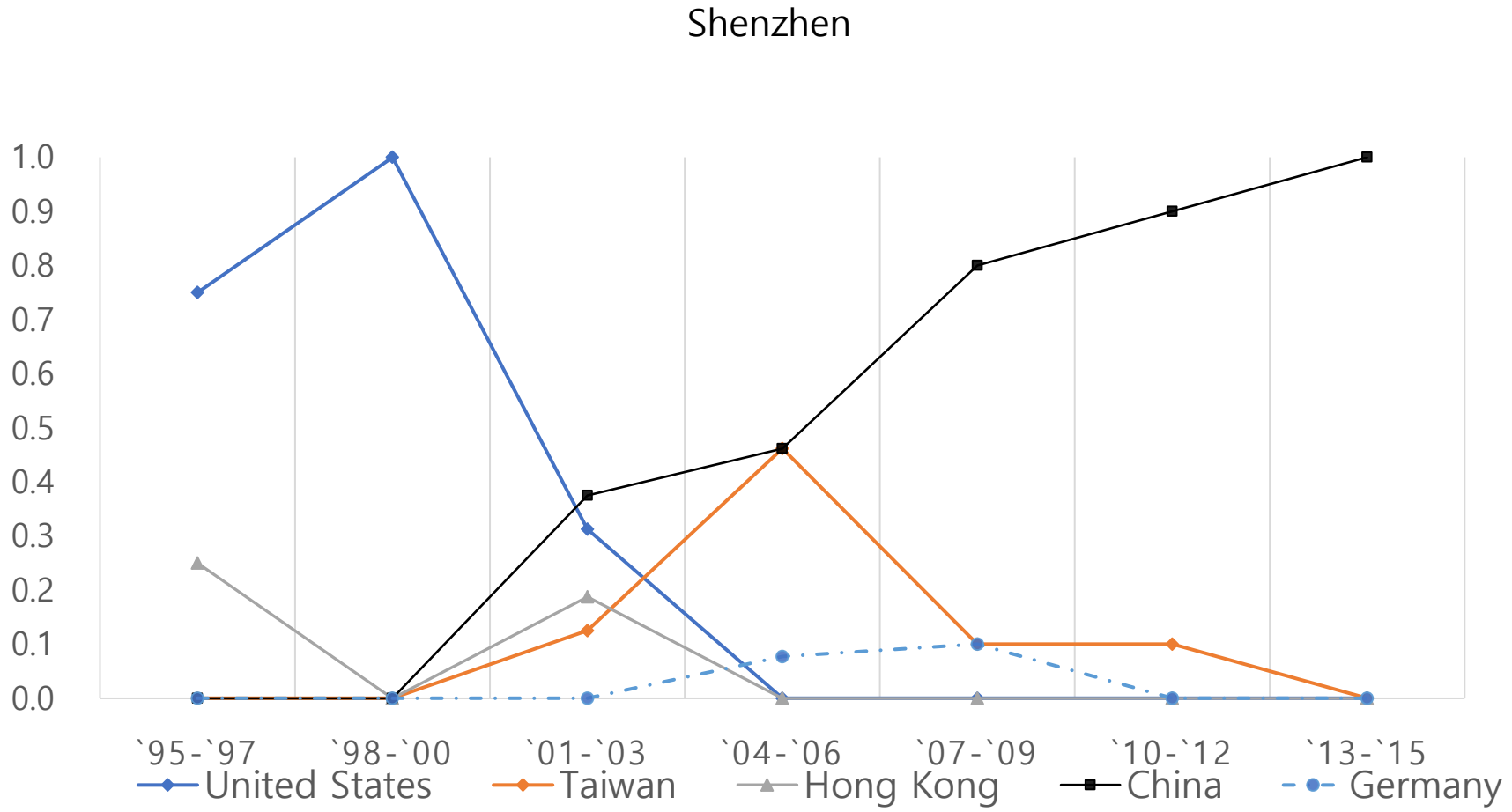
- Dominance of foreign MNCs in Penang seems to be related to the fact that the degree of originality is highest in Penang, compared to Shenzhen or Taipei.

The ratio of firms' nationality in top 10 assignee firms:
increasing share by locals in Taipei



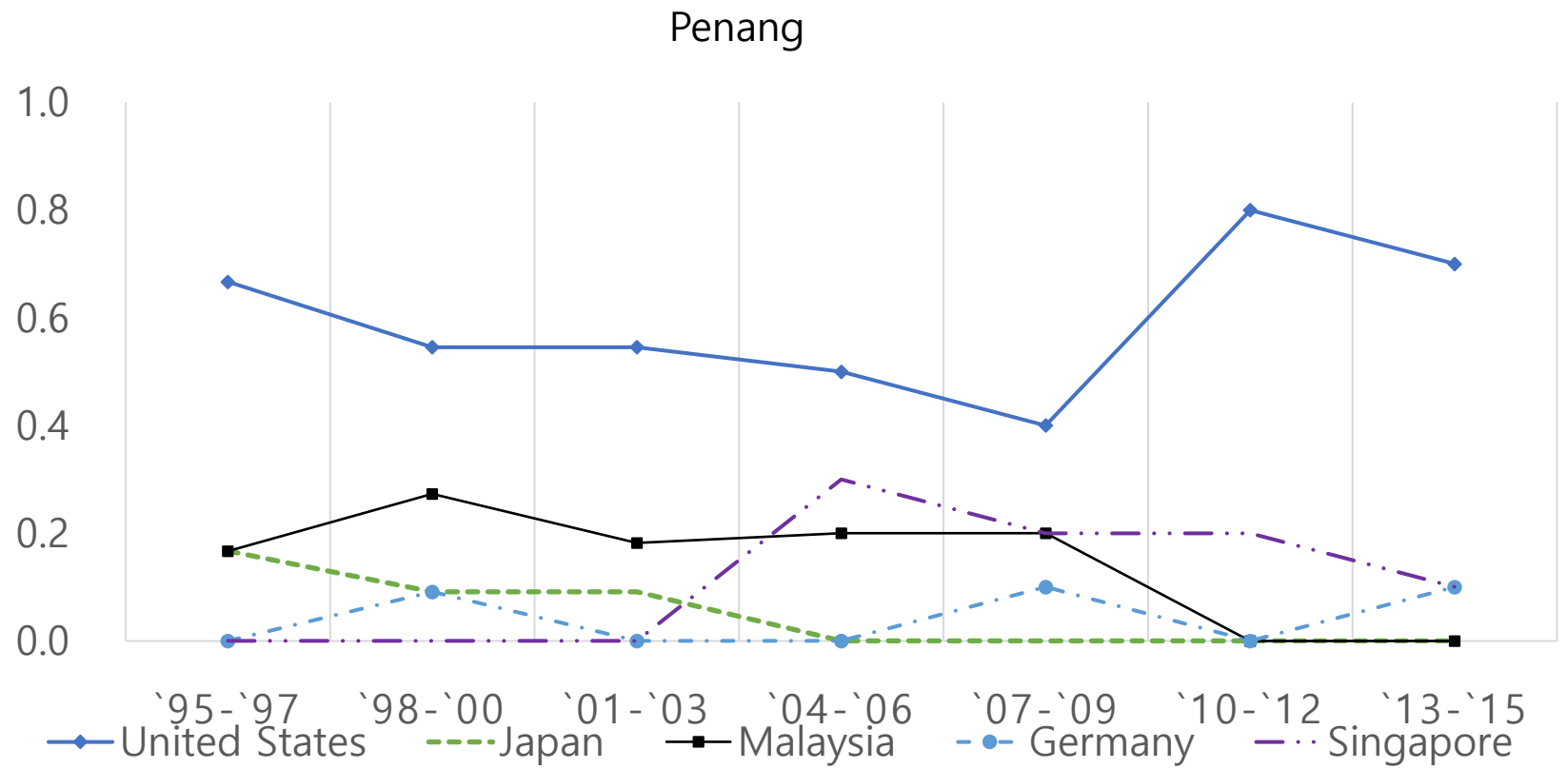
- **Taipei**: the dominance by the Taiwanese firms since the mid 1990s. .

The ratio of firms' nationality in top 10 assignee firms:
increasing share by locals in Shenzhen



- :kept increasing since the late 1990s; reached almost 100% during the 2013-2015.

The ratio of firms' nationality in top 10 assignee firms:
no increase of local ownership in Penang



- **<u>Penang</u>**: has remained dominated by the US firms with 50 to 70% shares since the 1990s to present
  - decrease of the shares by the Malaysian firms from 20% to zero in the mid 2010s.

Summary: three regions as alternative models of catching up RIS in terms of the local-global interface

▪Taipei and Shenzhen: a mode of eventually creating indigenous firms,

-in contrast to the Penang model of continuing reliance on MNCs.

-The former not easy to realize, but leading to a faster catching-up than Penang.

▪To promote locally-owned firms eventually, Taipei and Shenzhen have been more aggressive in terms of the degree of public intervention than Penang = a reasons for differences

▪If a latecomer region wishes a fast catching up,

▪To promote *localization of innovation and its ownership*,

after the initial stage of learning from foreign knowledge sources.

▪Various policy initiatives in Taipei and Shenzhen to promote indigenous innovation

-a) promote technology transfer from foreign to domestic firms,

-b) private and public joint R&Ds, and in-house R&D center by the local firms,

-C) attract branches of universities; encourage academic spinoffs / venture financing for them.

Varieties of RIS around the world

and Catch up by Latecomers,

30 cities around the world

- 7 European : Berlin, Munich, London, Cambridge, Stockholm, Paris, Milan, Moscow
- 4 USA : Silicon Valley (CA), Boston Area (MA), Austin , Houston
- 13 Asian : Shenzhen, Penang, Taipei, Tokyo, Beijing, Osaka, Seoul, Daejeon, Gyeonggi-do, Bangalore, New Delhi , Tel Aviv, Hong Kong, Shanghai, Singapore
- 3 Latin America: Santiago (Chile), Sao Paulo , Mexico City
- 1 Africa: Johannesburg

Variables in NIS and RIS

- Transform the NIS variables introduced in Lee (2013) and Lee et al. (2021) into regional level.
  - Five variables in NIS analysis, and seven variables in RIS analysis

NIS	RIS
Localization	Intra-regionalization (New)
	Inter-regionalization (New)
Internationalization (= 1- localization)	Internationalization (= 1- intra - inter)
Technological Diversification	Technological Diversification
Knowledge Decentralization	Knowledge Decentralization
Tech cycle tech. (sectoral specialization)	Technology cycle time
Originality	X
	Local ownership of knowledge (New)

Table 1 Average values of RIS Variables by region (annual average for 2013-2017)							
	Localization	Nationalization	Internationalization	Local ownership	Relative cycle time	Diversification	Decentralization
Paris	0.0518	0.0724	0.8758	0.7524	1.075	0.277	0.8912
Silicon Valley	0.2432	0.5183	0.2385	0.894	0.8736	0.5869	0.8251
Boston Area	0.0905	0.6268	0.2827	0.9405	0.9921	0.4719	0.8738
Austin	0.0711	0.6802	0.2487	0.9133	0.9079	0.3577	0.8053
Houston	0.186	0.5668	0.2472	0.9524	1.1215	0.4123	0.8944
Tokyo	0.1488	0.3154	0.5358	0.9528	0.9694	0.6283	0.9384
London	0.0009	0.0411	0.958	0.5721	1.003	0.2304	0.8833
Milan	0.0341	0.0358	0.9301	0.6235	1.1449	0.2199	0.924
Cambridge	0.0242	0.0381	0.9377	0.465	1	0.1962	0.8887
Taipei	0.1027	0.07	0.8273	0.8522	0.8511	0.4989	0.8325
Stockholm	0.0253	0.0691	0.9056	0.7603	0.8791	0.1543	0.7859
Munich	0.0253	0.0894	0.8853	0.7329	1.0305	0.3133	0.9148
Hong Kong	0.0436	0.0096	0.9468	0.255	0.9996	0.337	0.8779
Tel Aviv	0.0289	0.0728	0.8983	0.4977	0.893	0.1721	0.8364
Moscow	0.0519	0.005	0.9432	0.3721	0.9518	0.1679	0.8409
Berlin	0.0375	0.0734	0.8891	0.7151	1.0798	0.2778	0.9148
Seoul	0.0656	0.0881	0.8463	0.9678	0.8529	0.482	0.8173
Mexico City	0.0131	0.008	0.9789	0.6077	1.2113	0.0592	0.8152
Osaka	0.1045	0.3863	0.5092	0.9628	0.9881	0.5129	0.8305
Shenzhen	0.0408	0.0208	0.9385	0.9247	0.8165	0.3455	0.673
Gyeonggi-do	0.1154	0.0642	0.8205	0.9794	0.822	0.5243	0.7888
Penang	0.0341	0.0096	0.9563	0.0838	0.9031	0.0854	0.8329
Beijing	0.0448	0.009	0.9462	0.5504	0.8076	0.3624	0.8248
Daejeon	0.0467	0.0586	0.8947	0.9876	0.9426	0.3552	0.7033
Shanghai	0.0258	0.0154	0.9588	0.5277	0.897	0.3573	0.8077
Sao Paulo	0.0131	0.0058	0.9812	0.3685	1.1164	0.0968	0.8444
Santiago	0.0242	0.0019	0.9739	0.693	1.2377	0.0613	0.7915
New Delhi	0.0146	0.0209	0.9646	0.1962	0.8279	0.1053	0.8609
Bangalore	0.0136	0.0115	0.9749	0.1082	0.787	0.2152	0.9171
Johannesburg	0.0215	0.0240	0.9545	0.6650	1.1823	0.0537	0.7212
Average	0.0581	0.1336	0.8083	0.6625	0.9722	0.2973	0.8385

Cluster Analysis using the 7 RIS Variables: 4 Major Groups

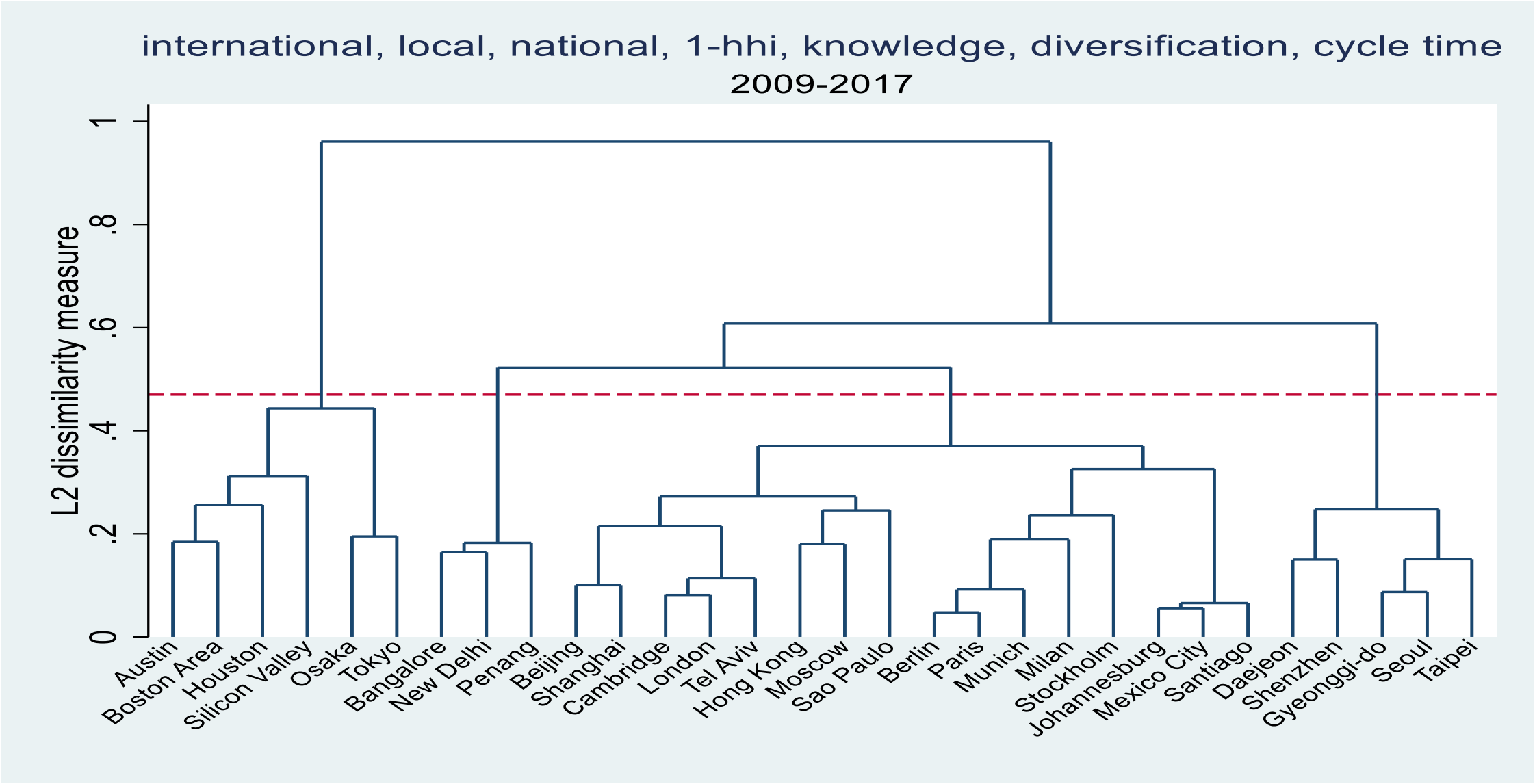


Table 2. Results of the Cluster Analysis: Using 7 RIS variables (level of dissimilarity : 0.449)		
	2000-2008	2009-2017
Group 1	Silicon Valley, Boston Area, Austin, Houston, Tokyo, Osaka	Silicon Valley, Boston Area, Austin, Houston, Tokyo, Osaka
Group 2	A: Paris, Berlin, Milan, Stockholm, Tel Aviv, London, Cambridge, B: Mexico City, Santiago, Sao Paulo, Johannesburg	A: Paris, Berlin, Milan, Stockholm, Tel Aviv, London, Cambridge, Munich B: Mexico City, Santiago, Sao Paulo, Johannesburg, Hong Kong, Moscow, Beijing, Shanghai
Group 3	Taipei, Seoul, Gyeonggi-do, Daejeon, Munich	Taipei, Seoul, Gyeonggi-do, Daejeon, Shenzhen
Group 4	Penang, New Delhi, Bangalore, Hong Kong, Moscow, Shanghai, Beijing, Shenzhen	Penang, New Delhi, Bangalore

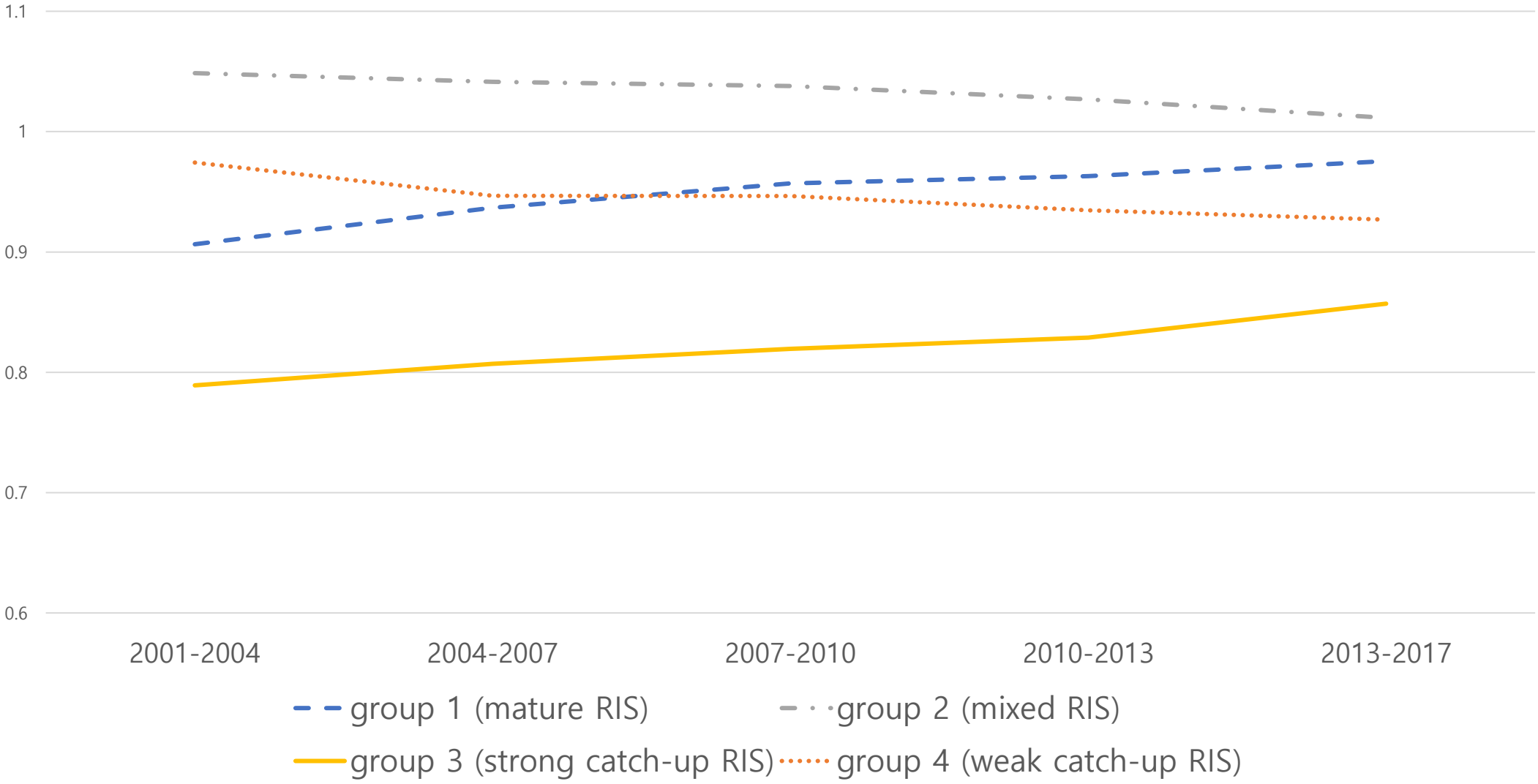
	Mature RIS (group 1) Long cycle & high ownership	Mixed RIS (group 2): Long cycle & mid ownership	Strong Catch-up (group 3): Short cycle & high local ownership	Weak Catch-up (group 4): Short cycle & low local ownership
International sourcing	**Low (0.32)**	**High (0.93)**	**Mid & decreasing (0.86)**	**High (0.96)**
Local ownership of knowledge	**High (0.94)**	**Mid (0.60)**	**high (0.94)**	**Low (0.20)**
Knowledge decentralization	**High (0.86)**	**High (0.86)**	**Lowest (=high concentration) (0.76)**	**Low (0.87)**
Technological diversification	**High (0.49)**	**Low (0.23)**	**High/increasing (0.44)**	**Low/increasing (0.17)**
Relative cycle time of tech	**Long (0.98)**	**Long (1.01)**	**Short (0.86)**	**Relatively Short (0.93)**

=> Two types of catching-up RIS at different stage

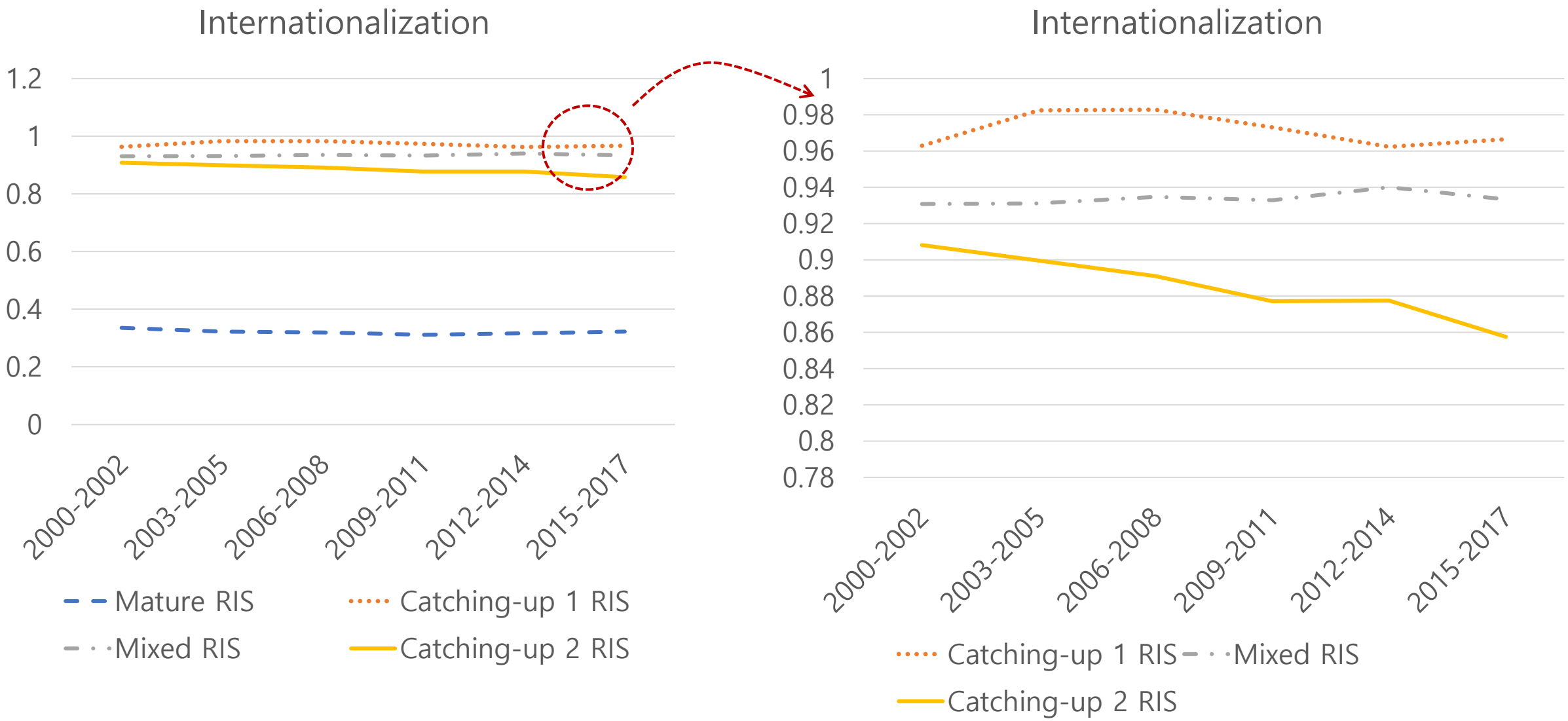
- Weak catching-up : low indigenous knowledge relying on FDI
- Strong catching-up : increasing local ownership by big businesses

Average values of RIS variables by group: average for 2013 to 2017										
2013-2017	Cities	Intra-region	Inter-region	Inter-national	Local ownership	decen tral	Diversi fic'n	cycle time	p. c. GDP	Growth p. c. GDP %
Mature RIS	Silic. Valley, Boston, Austin, Houston, Tokyo, Osaka	0.14	0.52	0.34	0.94	0.86	0.49	0.98	84592.7	2.27
Mixed RIS	Total 18 in this group	0.03	0.04	0.94	0.57	0.85	0.21	1.03	51658.4	4.44
	[A] Paris, London, Milan, Cambridge, Stockholm, Munich, Hong Kong, Tel Aviv, Moscow, Berlin	0.03	0.05	0.92	0.57	0.88	0.23	1.01	65571.8	3.33
	[B] Mexico City, Beijing, Shanghai, Sao Paulo, Santiago, Johannesburg	0.02	0.01	0.97	0.57	0.80	0.17	1.08	28469.4	6.30
Strong Catch	Taipei, Seoul, Shenzhen, Gyeonggi-do, Daejeon	0.07	0.06	0.87	0.94	0.76	0.44	0.86	43748.2	5.33
weak Catch	Penang, New Delhi, Bangalore	0.02	0.01	0.97	0.13	0.87	0.14	0.84	20173.9	10.36
Average		0.06	0.13	0.81	0.66	0.84	0.30	0.97	53778.5	4.75

Figure 2A Trends of Relative cycle time by group



Dynamic change: _International sourcing (=inverse of localization)
: lowest in mature = more local creation and diffusion of nowledge;



Dynamic change: _International sourcing (=inverse of localization)
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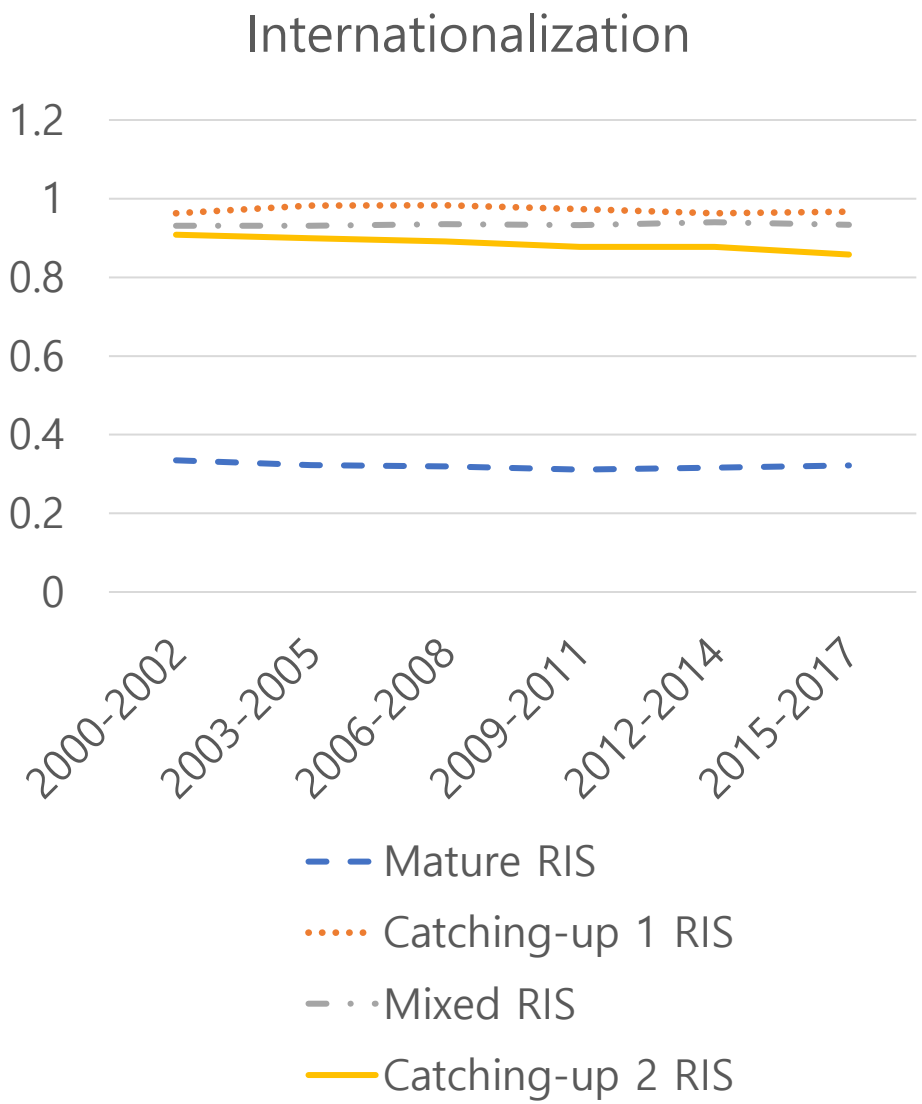
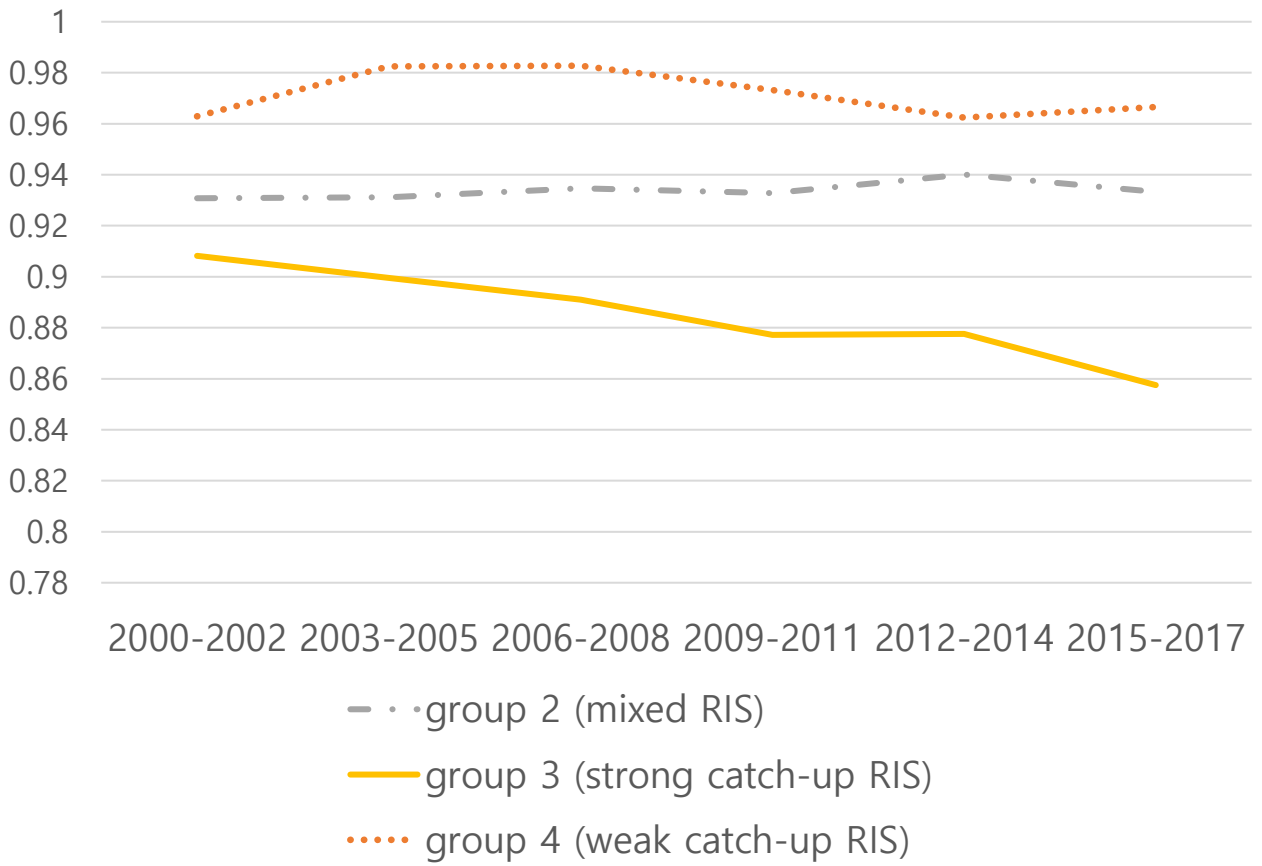


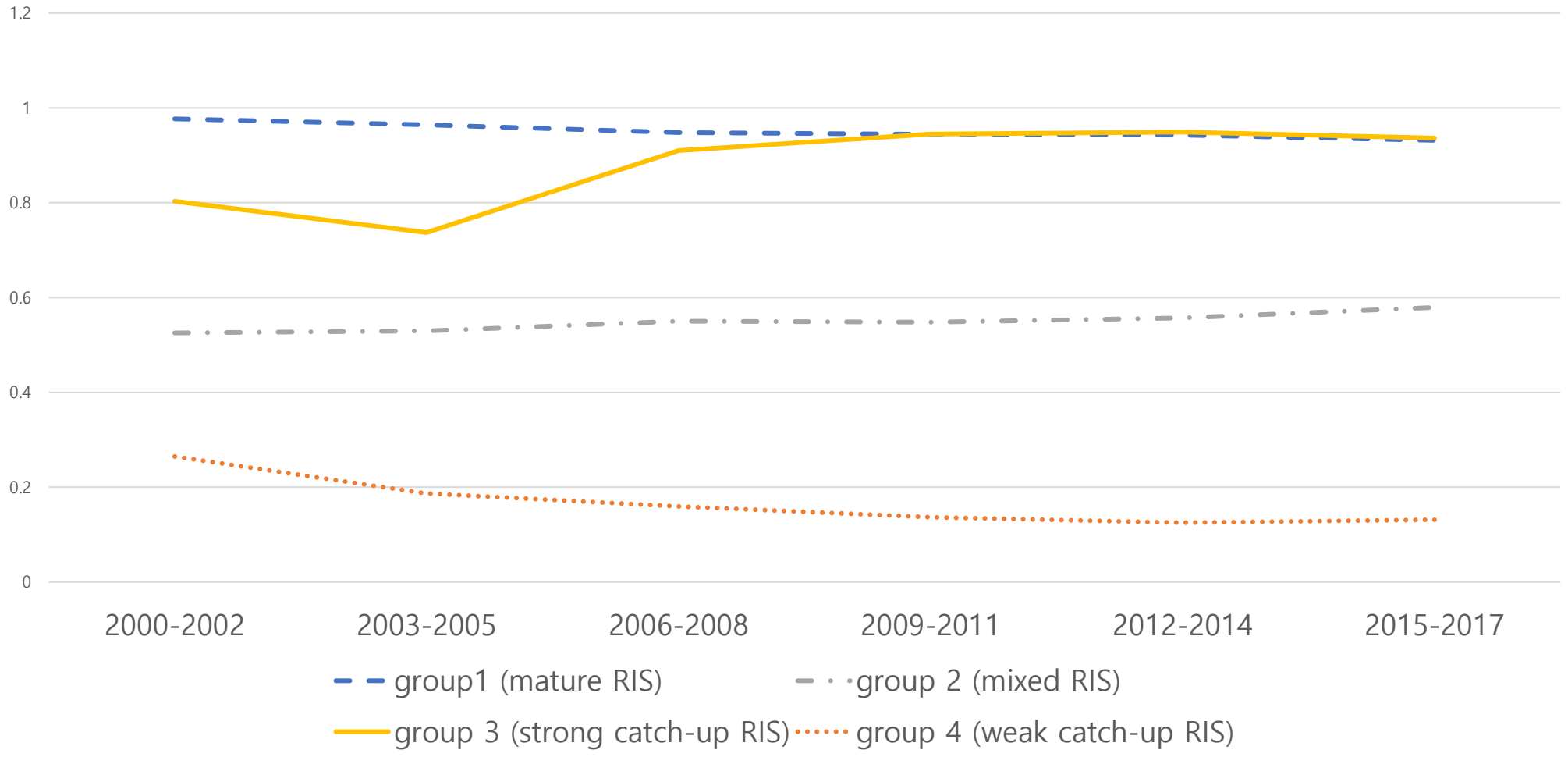
Figure 2C Trends of International Sourcing



Values for Group 1 (mature) ; below 40%; not shown here.

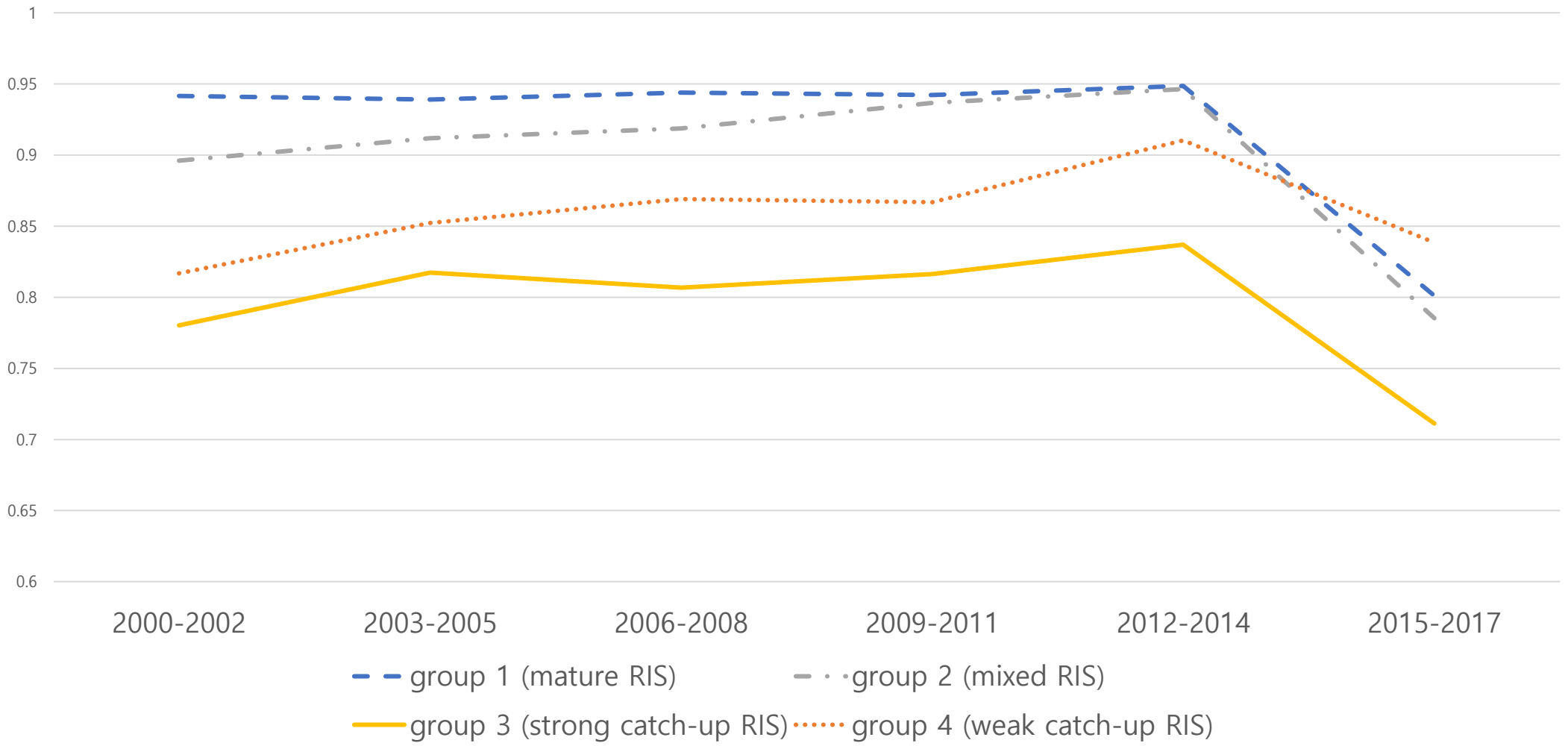
Dynamic change in Local ownership of knowledge

Figure 2B Trends of Local ownership of knowledge



Source: Author's calculation

Figure 2G Trends of Knowledge decentralization



Strong catch up led by big businesses (centralization than decentralization into SMEs)

Clustering over time : dynamic upgrading (dissimilarity = 0.449)					
	2001-2004	2004-2007	2007-2010	2010-2013	2013-2017
Mature, Large cities	Silicon Valley Boston Area Austin Houston	Silicon Valley Boston Area Austin Houston	Silicon Valley Boston Area Austin Houston Tokyo, Osaka	Silicon Valley Boston Area Austin Houston Tokyo, Osaka	Silicon Valley Boston Area Austin Houston Tokyo, Osaka
Transitory group 1	Tokyo, Osaka	Tokyo, Osaka			
Mixed group	Paris, London, Milan, Cambridge Taipei Stockholm, Munich Tel Aviv, Berlin, Seoul Gyeonggi-do Daejeon	Paris, London, Milan, Cambridge, Stockholm, Tel Aviv. Berlin, Mexico City. Sao Paulo, Santiago, Johannesburg	Paris, London, Milan Cambridge, Stockholm Tel Aviv, Berlin Mexico City Santiago, Johannesburg	Paris, Milan, Stockholm, Munich, Berlin, Mexico City Sao Paulo, Santiago, Johannesburg,	Paris, London, Milan Cambridge, Stockholm Munich, Hong Kong, Tel Aviv, Moscow, Berlin, Mexico City, Beijing, Shanghai, Sao Paulo, Santiago, Johannesburg
Strong catch up		Taipei, Munich Seoul Gyeonggi-do Daejeon	Taipei, Munich Seoul, **Shenzhen** Gyeonggi-do Daejeon	Taipei Seoul, **Shenzhen** Gyeonggi-do Daejeon	Taipei Seoul, **Shenzhen** Gyeonggi-do Daejeon
Weak catch up	Hong Kong. Moscow, Shenzhen, Penang, Beijing, Shanghai, New Delhi, Bangalore	Hong Kong, Moscow **Shenzhen**, Penang, Beijing, Shanghai, New Delhi, Bangalore	Hong Kong, Moscow Penang, Beijing, Shanghai, Sao Paulo, New Delhi, Bangalore	Bangalore, New Delhi, Penang, Beijing, Shanghai, Cambri, Tel Aviv, London, Hong Kong, Moscow	Penang New Delhi Bangalore
Transitory 2	Mexico City, Sao Paulo Santiago, Johannesburg				

Regressions of per cap GDP Growth: faster growth/catch-up than large mature RIS

	LSDV (4 groups)	GMM (4 groups)	LSDV (6 groups)	GMM (6 groups)
log(initial per capita GRDP)	-0.00259***	-0.00600	-0.00242**	-0.0296**
	(0.000901)	(-0.26)	(0.00111)	(-2.02)
No. of patents/1000	0.00754*	0.0188***	0.00741*	0.0185***
	(0.00386)	(2.96)	(0.00425)	(4.76)
population growth	0.952***	0.346	0.936***	1.024**
	(0.279)	(0.19)	(0.290)	(2.38)
mixed RIS	0.0446***	0.0704**	0.0443***	0.0422**
	(0.00623)	(2.50)	(0.00758)	(1.97)
strong catch-up RIS	0.0432***	0.0529*	0.0434***	0.0331**
	(0.00719)	(1.85)	(0.00812)	(1.97)
weak catch-up RIS	0.0937***	0.101**	0.0952***	0.0575**
	(0.0139)	(2.30)	(0.0157)	(2.55)
Transitory group 1			-0.000967	0
			(0.00816)	(.)
Transitory group 2			0.0801***	0
			(0.0113)	(.)
Constant		0.0307		0.296*
		(0.12)		(1.87)
adj. R^2	0.734		0.731	

Importance of local ownership for Catchup; by localization & diversification

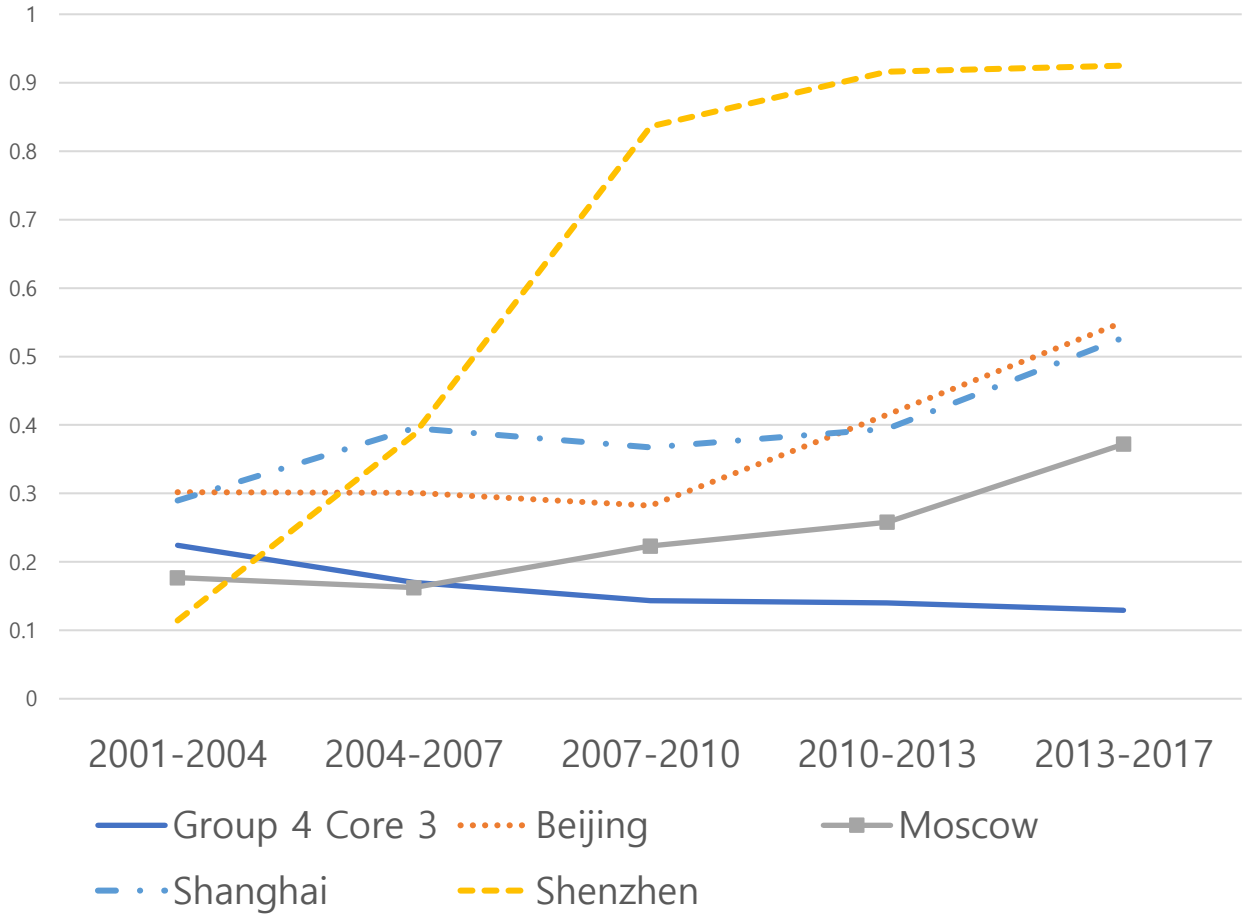
- In NIS analysis,, catching-up NIS specialize in short cycle technologies, high localization and diversification .
- in RIS analysis, both (weak & strong) catching-up RIS groups specialize in short cycle technologies;

-but, weak group still low localization, diversification.

- ***Why?*** Answer) Difference in ***"local ownership of knowledge"***;

=. Not only cycle time but ownership matter

Figure 3A Local ownership of knowledge



Core 3 include Bangalore, New Delhi, and Penang

Key findings

- Regions in ***4 groups***,
  - Mature RIS, Mixed RIS, strong Catching-up RIS, Weak Catch-up 2 RIS.
- Two types of catching-up: catching-up 1 RIS, catching-up 2 RIS

  1) Weak Catching-up: faster than mature, but lowest level of per capita GDP

  (lack of indigenous knowledge -> relying on external knowledge)

  2) Strong Catching-up: faster than mature, & higher level of per capita GDP than catching-up 1

  (increasing indigenous knowledge -> decreasing dependency on foreign knowledge)
- For latecomers, economic growth by relying on FDIs/MNCs easy but limited in long run.

  (advanced countries or firms are reluctant to transfer knowledge : Lebdioui et al., 2021; Lee, 2005).

- ***Indigenous knowledge is a base for increasing localization of knowledge, which is the basis for innovation.***
- **How?** Promote local big businesses and have them to create own knowledge
  - Strong Catching-up RIS: show a higher concentration of knowledge creation

Thank you!

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